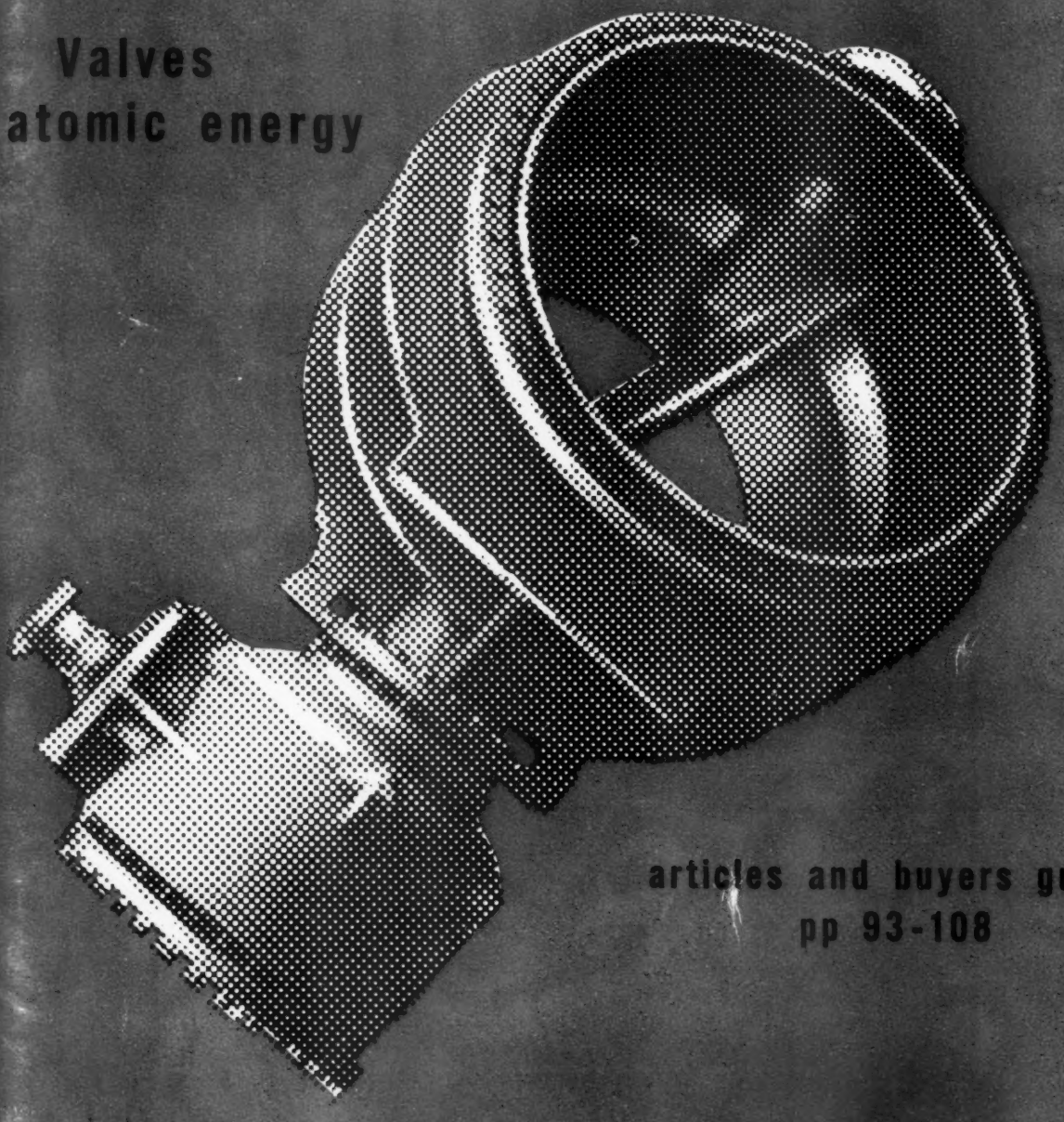
A ROWSE MUIR PUBLICATION

uclear Power

REACTORS · MATERIALS · INSTRUMENTATION · PROCESSES · RADIATION

Valves
r atomic energy



articles and buyers guide
pp 93-108

tember 1960 monthly 3/6

HOWDEN

Specialists in the design and manufacture of equipment for

MOVING OR COMPRESSING AIR AND GASES

TRANSFERRING HEAT FROM ONE FLUID TO ANOTHER

CLEANING AIR AND GASES

JAMES HOWDEN AND COMPANY LTD

195 SCOTLAND STREET, GLASGOW, C.5, and
15 GROSVENOR PLACE, LONDON, S.W.1

Circle **No 1** on reply card for further details

LIBRARY

Nuclear Power

REACTORS · MATERIALS · INSTRUMENTATION · PROCESSES · RADIATION

VOL 5 NO 53 SEPTEMBER 1960

MANAGING DIRECTOR A. H. David Rowse, MA
EDITORIAL DIRECTOR Caldwell Davidson, MSC(ENG), DIC

EDITORIAL
EDITOR John Woodeson, BSC(ENG)
ASSISTANT EDITOR J. Spencer Burkett, FLA
TECHNICAL EDITOR David Iggulden, BSC
NEWS EDITOR Sidney Hollands, BCOM
EDITORIAL ASSISTANT M. E. Wilson

CONSULTANTS
INSTRUMENTATION Denis Taylor, PHD, MIEE, FIP
PHYSICS James F. Hill, BSC
METALLURGY Prof. J. G. Ball, BSC, FIM
ISOTOPES A. G. Maddock, MA, PHD, DIC

INDUSTRY GUIDE AND DIGEST NUMBER
EDITOR Charles E. Steiner

PRODUCTION
PRODUCTION MANAGER Gerald Vane, BA (CANTAB)
ASSISTANTS A. E. Hammond, Gerald Withers

CIRCULATION
MANAGER J. W. Rotheroe, BSC(ECON)
ASSISTANT B. W. Stapley

ADVERTISEMENTS
DIRECTOR Harry T. Kane
MANAGER John Abram
SOUTHERN REPRESENTATIVE K. M. Towell
CLASSIFIED John Deamer

MANCHESTER OFFICE
Barry Gibbs
72 Market Street, Manchester 2
tel: Blackfriars 4058
Blackfriars 1919

NEWCASTLE OFFICE
Peter Doig
17 Westgate Road, Newcastle 1
tel: Newcastle 24266

PARIS OFFICE
M. B. Lebovic & G. Leterrier,
36 rue du Fer-à-Moulin,
Paris 5eme, France
tel: POR 53-39

U.S. OFFICE
Walter J. Masterson, Jr
Box 206 Essex, Conn. *tel:* South 7-1838

HEAD OFFICE
The Rowse Muir Building,
77-79 Charlotte Street,
London, W.1, England
tel: Museum 8252
cables: ROWSEMUIR LONDON

NUCLEAR POWER is published by Rowse Muir Publications Ltd. and printed by The Haycock Press Ltd, SE5. The entire contents are protected by copyright in Great Britain and by the Universal Copyright Convention but matter may be reproduced provided that due acknowledgment is made to NUCLEAR POWER. Subscriptions to publishers Rowse Muir Publications Ltd. Single copies UK and overseas 3/6, US and Canada 75c. One year's subscriptions UK and overseas £2.2.0, USA and Canada $8.00. Three years' subscriptions UK and overseas £5.0.0, USA and Canada $20.00.

SPECIAL FEATURES

VALVES IN ATOMIC ENERGY

Valve types and applications
NUCLEAR POWER's *Technical Editor, Mr. D. Iggulden, briefly reviews some of the engineering problems* 93

Gas valves for nuclear power stations
Gas-cooled reactors presented valve manufacturers with new problems. Mr. C. D. Blakeborough here outlines how these are overcome 96

Corrosion resisting valves
The choice of suitable materials and the design features of valves for processing plants is discussed by Mr. H. E. Threlfall 100

Valve buyers guide
Who makes valves for the atomic energy industry? NUCLEAR POWER *lists types supplied and their makers* 103

Classification rules for nuclear ships
A Lloyd's 'charter' for designers is summarized 92

US-Euratom research
Forty-five projects begin the joint programme 92

Automatic control conference in Moscow
Ifac's first Congress, attended by over 1000 people, is reported by Mr. P. K. M'Pherson of the AEE, Winfrith 109

Steam cycles for power reactors—1
After examining the merits of different cycles Mr. W. J. Thomas of Kennedy & Donkin looks at the choice for magnox reactors 110

Brookhaven High Flux Beam Reactor
Neutron beams of the highest possible 'quality' is the object of this new design 113

NUCLEAR TECHNOLOGY

Predicting fuel element lifetime
The statistical method of predicting fuel element failure rates, described by Mr. J. K. Davidson and Mr. L. H. Devlin, aims at avoiding overdesign 118

Radiation effects in cladding materials
Mr. R. S. Barnes of AERE, Harwell, discusses the changes in mechanical properties created by fast neutron bombardment 122

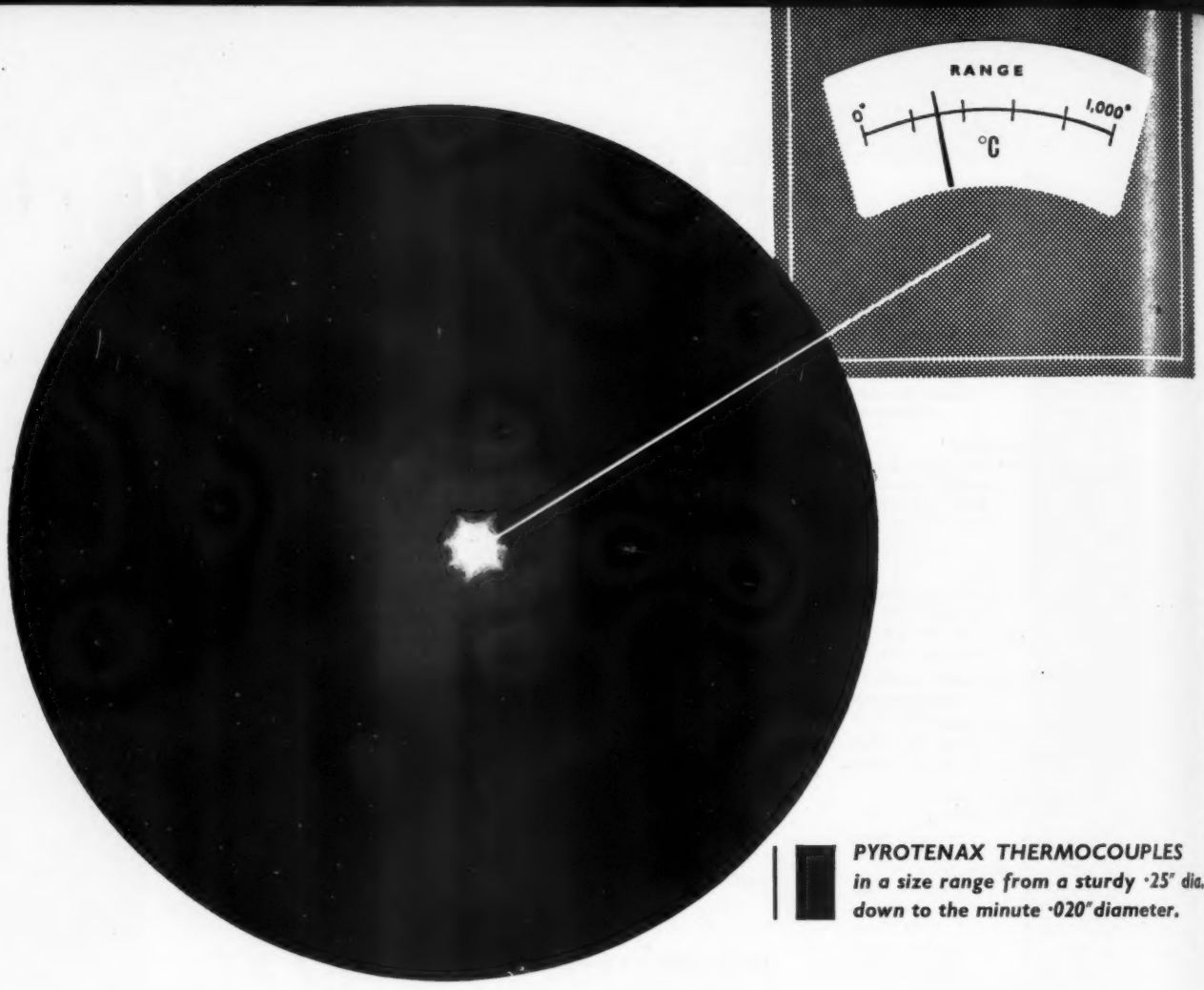
REGULAR FEATURES

Progress in industry
Winfrith's new exponential assembly, steam test loop for NRU, metal-fibre UO_2 elements 114

Letters	81	Students' Notebook	128
Editorial	83	Business News	130
Worldview	85	Diary	132
Points from Papers	117	Industrial Literature	132
Cross-Section *Gracchus*	124	People	134
New Product Survey	125	Book Reviews	136

LOOKING FOR A JOB? SEE PAGE 182 AND ONWARDS

RM ROWSE MUIR PUBLICATIONS LIMITED, LONDON, ENGLAND



***PYROTENAX THERMOCOUPLES** in a size range from a sturdy ·25" dia. down to the minute ·020" diameter.*

There is something here for every industry where temperature has to be measured—

The inherent qualities of Pyrotenax thermocouples, which were essential to the exacting requirements of nuclear power, are equally attractive to the industrial user. The temperature range is sub-zero to 1100°C., sizes ·25" down to ·020", with many alternatives of sheath and conductor metals.

- ***Small overall diameter***
- ***Rapid Response Rate***
- ***Easily bent to shape***
- ***Immune from thermal shock and mechanical damage***
- ***No additional protective sheathing required***
- ***Long life—inexpensively replaced***

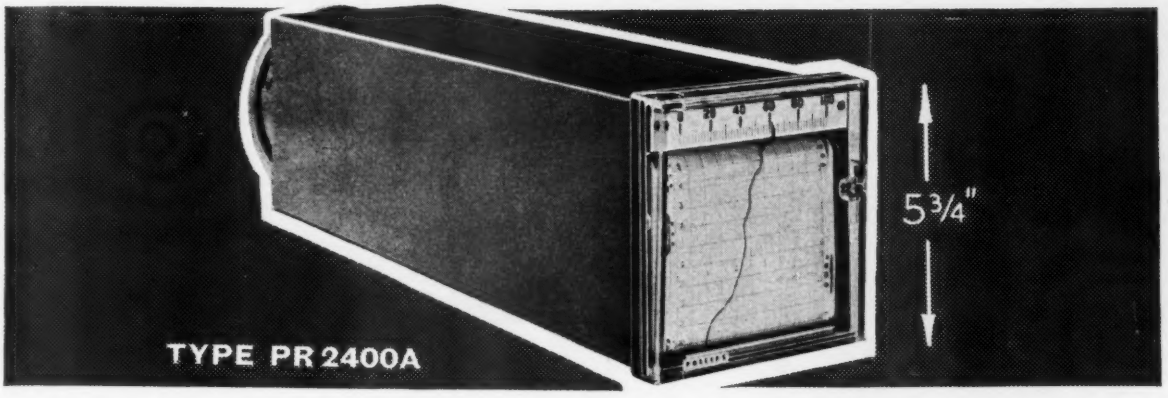
PYROTENAX LIMITED ● **HEBBURN-ON-TYNE Telephone: Hebburn 83-2244**
LONDON: VICtoria 3745 · **BIRMINGHAM:** Midland 1265 · **MANCHESTER:** Deansgate 3346/7 · **LEEDS:** Leeds 27826 · **GLASGOW:** City 3641/2 · **CARDIFF:** 23689

GD—207

PERFECTED BY EXPERIENCE
Pyrotenax
m.i. THERMOCOUPLES

The use of the trade name Pyrotenax is exclusive to the products of this Company and its associates.

PHILIPS
MINIATURE RECORDER



FEATURES Small panel space of 144 x 144 mm (approx. 5¾" x 5¾") · Reliable null-balancing potentiometer system · Easily interchangeable ranges · Transistorized plug-in amplifier with printed wiring · Unique chart-winding system · High indicating speed and critical damping · Scale calibration for mV or all conventional thermocouples · Completely mains operated.

RECORDING SECTION Strip chart, width 100 mm, length approx. 9 m. The chart is wound into an exchangeable casette. Visible length of 100 mm. After opening the door the chart can be pulled out over a length of 80 cm. Chart returns automatically into the casette.

CHART-SPEED With built-in gear box 3 different speeds can be selected: 10, 20 and 60 mm/h. Can be supplied with electro-mechanical clutch so that by means of external switch, chart movement can be accelerated by a factor of 60.

This photograph shows the lighter weight and compact size of the plug-in transistorized amplifier.

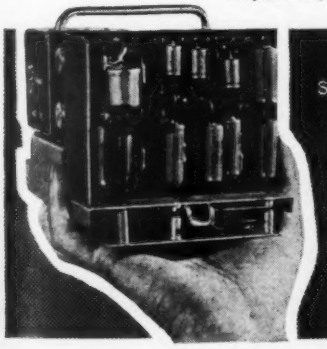
Miniature mV-Recorder

MINIMUM SPAN 5 mV · MAXIMUM SPAN 250 mV
ACCURACY 0·5%; the accuracy can be maintained after exchange of range box.
REPRODUCIBILITY 0·2% of span · SCALE LENGTH 100 mm.
STABILITY 10% mains variations have an influence of less than 0·1%
BALANCING SPEED Less than 1 sec. for full scale deflection; damping critically adjustable.

RECORDING With flexible capillary stylus supplied from sealed ink container mounted under measuring carriage. Line thickness approx. 0·3 mm.

CONSTRUCTION Sheet-metal case in grey hammertone with all plastic door. Front dimensions 144 x 144 mm; depth 510 mm; panel opening 138 x 138 mm. (5¾" x 5¾"—20"—5½" x 5½").

PRODUCT OF PHILIPS, EINDHOVEN, HOLLAND



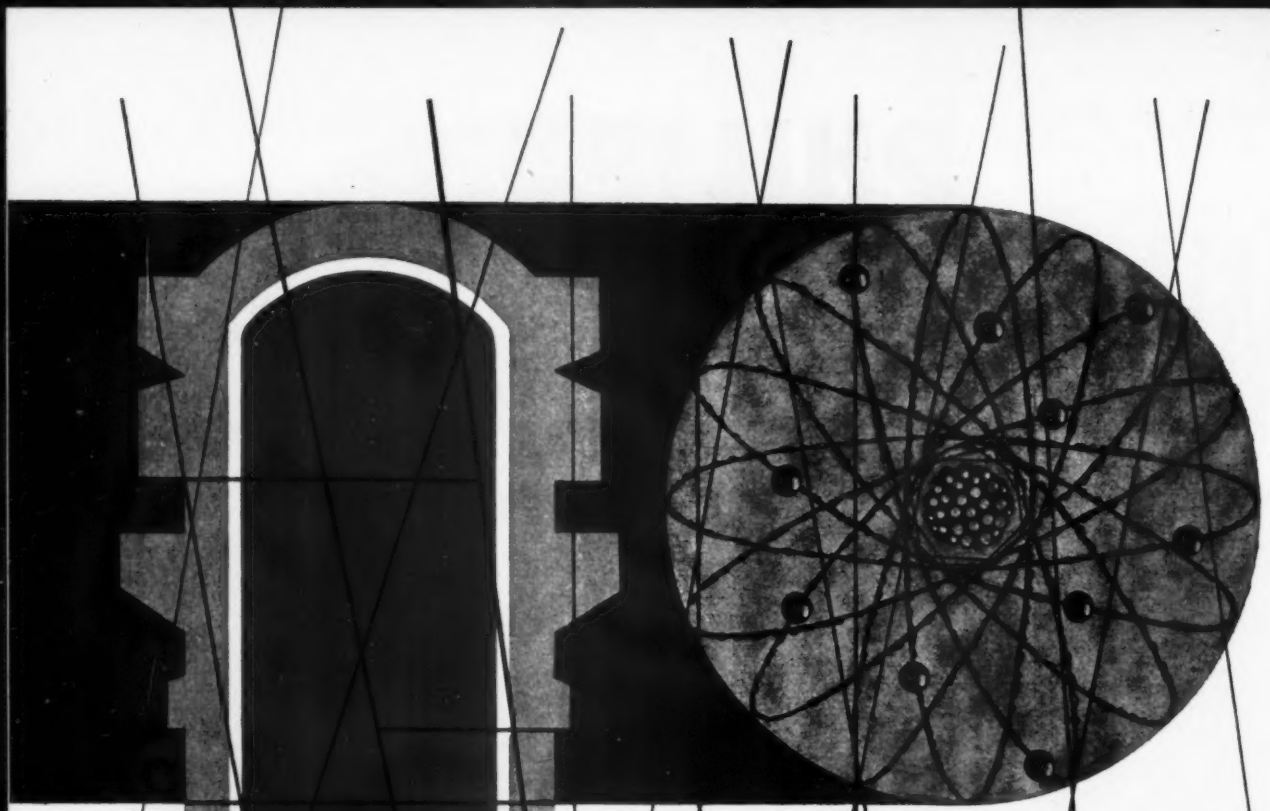
SOLE DISTRIBUTORS IN U.K

RESEARCH & CONTROL INSTRUMENTS LTD

Instrument House · 207 Kings Cross Road · London · W.C.1.

Telephone: Terminus 2877

(RCL0009)



Clad plate is used in the construction of **Nuclear Power Stations.**

We supply **Clad Plate** in individual plates of up to 20 tons weight and up to approx. 10 in. (250 mm) thickness for the construction of nuclear power plant.

PHOENIX-RHEINROHR AG

VEREINIGTE HÜTTEN- UND RÖHRENWERKE DÜSSELDORF
GERMANY

Circle **No 4** on reply card for further details

International NU-SWIFT News

No. 3

HAVE YOU MET THESE PEOPLE?

39. The UNITED KINGDOM ATOMIC ENERGY AUTHORITY has protected DOUNREAY EXPERIMENTAL REACTOR ESTABLISHMENT in remote CAITHNESS in the North of Scotland with reliable Nu-Swift. The U.K.A.E.A. has some fire risks: The fire in 1957 at their Windscale No. 1 pile cost £1,967,826.

40. KUNGL. SJÖFARTSSTYRELSEN, progressive Sweden's Ministry of Transport, responsible for safety of life at sea according to the 1948 London Convention, was first maritime authority to approve Nu-Swift 30 lb. Dry Powder Extinguisher, Model 1630, for use afloat. Approval is conditional upon spare charges also being carried.

41. Sir HUGH CASSON, famous British architect and exponent of MODERN DESIGN, is one of the many professional men whose premises are protected by Nu-Swift.

42. Rendez-vous of the cosmopolitan smart set, the famous Palace Hotel, ST. MORITZ, Switzerland, near the Cresta Run, is now protected by Nu-Swift. So are many of the vessels of the rich GREEK SHIPOWNERS who made the Palace Hotel their winter headquarters.

43. Norwegian WHALE CATCHING SHIPS each year set out from SANDEFJORD, Norway, destined for hazardous adventures in ANTARCTICA. Six or nine months later they return after incredible hardship, but often with the pockets of the crew lined with gold. Most whalers and floating whale factories are equipped with reliable Nu-Swift.

44. In lovely GREENLAND, no longer merely the home of eskimos, and a colony, but part of the kingdom of Denmark, with output from cryolite mines becoming of increasing economic importance, trading posts of the ROYAL GREENLAND TRADING CORPORATION have been equipped with Nu-Swift.

45. The HOME OFFICE FORENSIC LABORATORY at PRESTON, LANCS., ENGLAND, famous for its fact-searching work in many murder trials, has been equipped with Nu-Swift.

46. Now also available with instructions in ARABIC, Nu-Swift extinguishers can be specified with instructions in this and any of 13 OTHER LANGUAGES at no extra charge.

47. PUNCH, the famous weekly, in recent years brightened by a face-lift, is now also, to prevent possible interruption in publication, protected by Nu-Swift. So are the giant presses in the three cities of publication of the DAILY EXPRESS, printed simultaneously every day in 4,000,000 copies, in LONDON, MANCHESTER and GLASGOW.

48. In GUATEMALA, prosperous Central American State, all the BANKS, except one, are protected by reliable Nu-Swift.

49. SOCIETE NATIONALE DES CHEMINS DE FER BELGES (The BELGIAN STATE RAILWAYS) have, after extensive laboratory tests in BRUSSELS by SOFINA, placed their first substantial orders for Nu-Swift extinguishers.

50. In the unhappy event of another global war, many CIVIL DEFENCE EXPERTS believe that the self-contained Nu-Swift Universal (Royal Navy) 2-gallon Water/CO_2 extinguishers will be of great value in dealing with the many small fires likely to flare up at some distance from a THERMO-NUCLEAR EXPLOSION, at a time when public water supplies will probably be interrupted.

HAVE YOU BEEN TO THESE PLACES?

51. Where only a century ago, native warriors, with unexampled ferocity, fought the white man in ZULULAND, local farmers are now forming themselves into Nu-Swift fire fighting groups of five to pool their Nu-Swift fire posts and jointly combat attacks of the equally ferocious Fire Fiend. Twenty-nine such groups have so far been organised; they have proved themselves of great value in defeating dangerous SUGAR CANE FIRES.

52. Through the failure of old soda acid extinguishers, CLOVER MEATS LTD., WATERFORD, Republic of IRELAND, a firm which does a large export business, lost a contract worth £80,000. In consequence, 69 soda acid extinguishers were scrapped, and, instead, reliable Nu-Swift was installed to the tune of £1,500.

53. The private railway coach of President KEKKONEN, the first citizen of democratic FINLAND, is now protected by effective, and reliable Nu-Swift Dry Powder Extinguisher, Model 1604.

54. 'Guinness is good for you' says the famous slogan of the GUINNESS BREWERY, in Dublin, a national institution in the Republic of IRELAND. The brewery is now protected by Nu-Swift, and that, of course, is good for GUINNESS!

55. Founded in 1843, the NATIONAL METSOVIAN POLYTECHNIC SCHOOL in ATHENS, GREECE, the largest and most important scientific institution in South Eastern Europe and the Middle East has, after exhaustive investigation, decided to standardize on Nu-Swift extinguishers. Initial order was obtained in the teeth of keen local, German, American and Italian competition.

DISASTROUS FIRES CRIPPLE INDUSTRY,

— only reliable NU-SWIFT *when fire threatens* is good enough for your business!

Ask for your copy of our new 94-page, illustrated catalogue:

Easy-to-handle, certain-to-operate Fire Fighting Equipment

nu-swift ltd · elland · yorkshire · england

Serving mankind in more than 70 countries

TAKING THE LOAD

Sections from Skinningrove have been used and relied upon by major industries in many parts of Britain and abroad. We pride ourselves in taking the closest personal interest in our customers' requirements.

We shall be pleased to forward a copy of our Section Book on request.

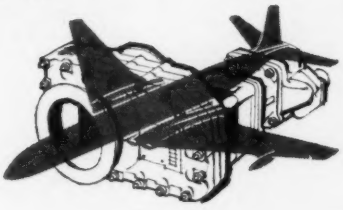
The illustration above shows transmission towers on the 275kV. Hinkley Point to Melksham Line. Fabrication and Galvanising carried out by Painter Brothers Ltd. of Hereford, to whom our sections were supplied. Main contractors : British Insulated Callender's Construction Company Ltd. Tower designed by Blaw Knox Ltd.

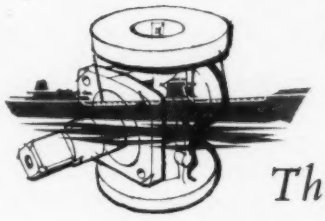
SKINNINGROVE

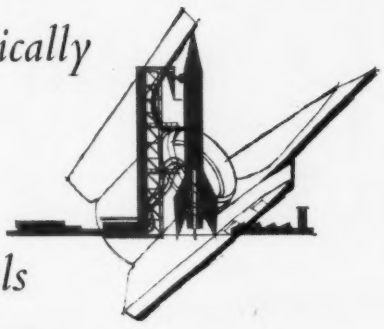
IRON COMPANY LIMITED

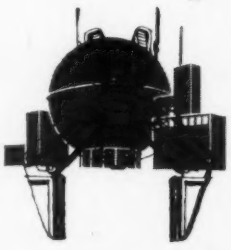
PO BOX NO 1 SALTBURN YORKSHIRE TELEPHONE LOFTUS 212

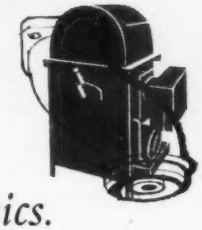
Kanigen *a hard, non-porous corrosion-resistant plate, gives complete uniform coverage even to the most intricately shaped parts. Thickness can be controlled to fine limits. Being chemically deposited Kanigen can be applied to practically all metals in commercial use. It can also be applied to non-conductors such as plastics and ceramics.*











KANIGEN
ALBRIGHT & WILSON

Approved under DTD 900/4505 and ARB A1/5112/57. Already widely used throughout industry including aircraft and nuclear applications. Kanigen is the registered trade mark of Albright & Wilson (Mfg) Ltd.

For full information write to:

ALBRIGHT & WILSON (MFG) LTD

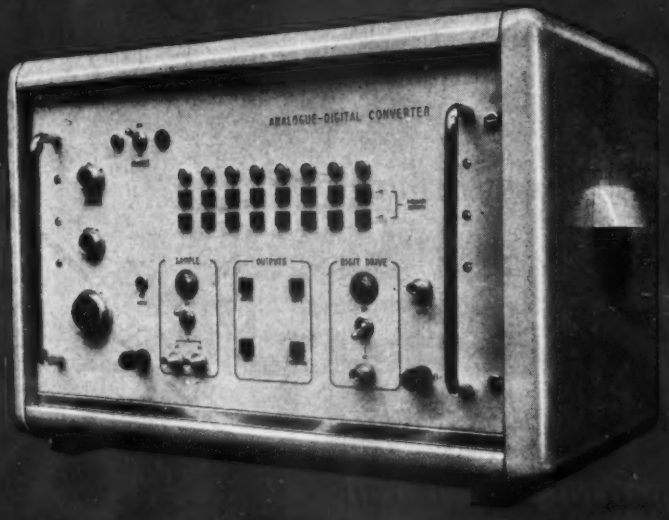
Kanigen Department (NP)

1 KNIGHTSBRIDGE GREEN · LONDON SW1 · TEL KENSINGTON 3422

xaw/701

THE A.W.E. ANALOGUE TO DIGITAL CONVERTER

For fast accurate transmission of data...



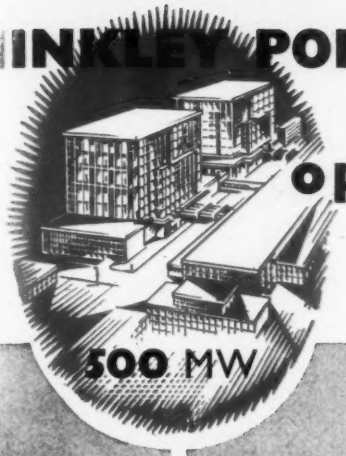
★ Extremely High Speed
★ Flexible and Reliable
★ Low Power Consumption
★ Fully Transistorized
★ Suitable for Rack Mounting
★ Easy Servicing

The A.W.E. Analogue to Digital Converter, type A.D.C.1., by performing up to 55,000 conversions a second, prevents bottlenecks caused by lack of speed—the main drawback in incorporating such converters in a system. An 8-bit binary converter, the A.D.C.1. provides a reliable link between the two forms of signal.
Transistors are used throughout the unit to ensure resistance to shock and vibration, and plug-in boards allow rapid and easy servicing.

Specifications include provision for both serial and parallel digit outputs and for external sample and digit drive. The accuracy of the unit is $\pm \frac{1}{2}$ the least significant digit $\pm$ 0.25% over a temperature range of 0-40°C. Units can be supplied to accept analogue inputs whose scale factors range from 0-6V to 0-60V. Total power consumption is only 11 watts from a nominal 230V supply. Overall dimensions of the unit are 19 ins. x 10.5 ins. x 12 ins.

ARMSTRONG WHITWORTH EQUIPMENT TEL: GLOUCESTER 66781 TELEX 4313
SIR W. G. ARMSTRONG WHITWORTH AIRCRAFT LIMITED., A MEMBER OF THE HAWKER SIDDELEY GROUP

HINKLEY POINT



operation PROGRESS

Lifting the 325-ton shell of the first steam-raising unit into position at Hinkley Point, the world's first 500 MW atomic power station now under construction for the Central Electricity Generating Board. Twelve of these 90 ft. high units built by Babcock & Wilcox will provide steam to drive the station's turbo-alternators. The steam-raising units are built in the site workshops from prefabricated sections and lifted into position by the 250 ft. high, 400-ton capacity Goliath crane which straddles the reactor buildings.

150 MW

250 MW

Progress by this Group, designers and builders of the world's first 500 MW atomic power station, is being made not only at Hinkley Point but also to meet export requirements. For stations of similar type for construction overseas, detailed design studies have been completed for outputs of 150 MW and 250 MW.

ENGLISH ELECTRIC

THE ENGLISH ELECTRIC COMPANY LIMITED
Marconi House, Strand, London, W.C.2

BABCOCK & WILCOX

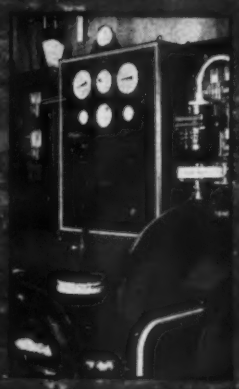
BABCOCK & WILCOX LIMITED
Babcock House, Euston Road, London, N.W.1

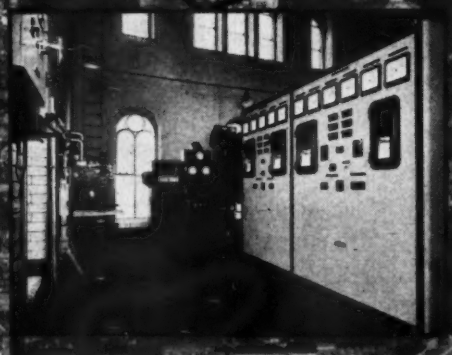
TAYLOR WOODROW

TAYLOR WOODROW CONSTRUCTION LIMITED
London

GA. 9

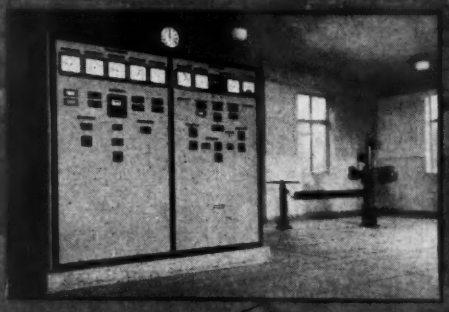
Circle **No 9** on reply card for further details





REMOTE INDICATION

for WATER · OIL · CHEMICAL



Evershed supervisory control units enable up to 40 plant functions to be remotely controlled over two wires—with indications and alarms operating in the opposite direction over the same two wires. The system is self-monitoring and constantly checks its own synchronization. It also provides for telephone communication—*again over the same two wires.* The illustrations show panels in use at Colchester where remote and local water reservoir levels are indicated and recorded and distant control valves and borehole pumps are operated automatically. This telemetering system makes Colchester Corporation's Water Works one of the most up-to-date in Great Britain.

& CONTROL

EVERSHED

GAS • POWER • NUCLEAR • SEWAGE

INTERNATIONAL INSTRUMENT MANUFACTURERS & CONTRACTORS

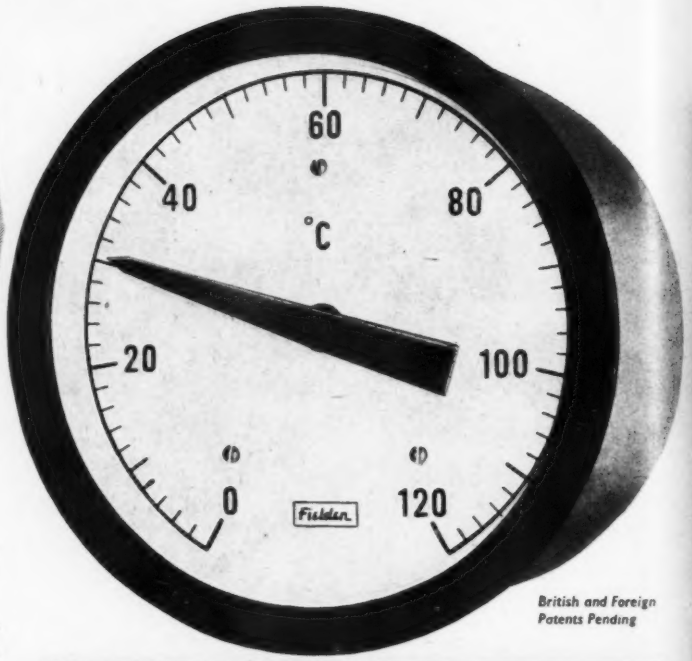
EVERSHED & VIGNOLES LIMITED

ACTON LANE WORKS · CHISWICK · LONDON W4

Chiswick 3670 · Cables · Telex

NUCLEAR POWER September 1960 Circle No. 11 on Reader Service Card

NEW



British and Foreign Patents Pending

VERY ROBUST. Sealed 6" diameter instrument, with measuring bulb in ¼" diameter stainless steel sheath.

LOW COST. A practical and economic replacement for filled systems and moving coil instruments — send for price list.

TRANSISTORISED. Exceptional reliability with a printed circuit and robust motor driven indicating pointer. 12 volt battery or mains supply.

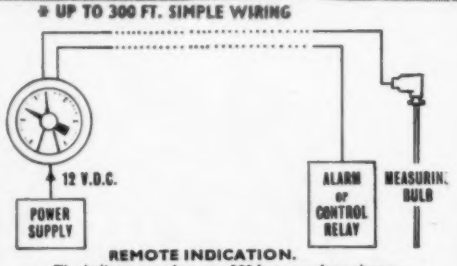
EASILY FITTED. Simple clamp mounting with robust terminals. No fragile capillary tubes or expensive compensating cable — simple wiring only required.

ACCURATE AND RAPID RESPONSE. Reproductibility better than 0·25% on 13" scale, response time 1 second.

73 TEMPERATURE RANGES in °F and °C for temperatures up to 850°C.

'BIKINI' TEMPERATURE INDICATOR

UP TO 300 FT. SIMPLE WIRING



REMOTE INDICATION.
The Indicator can be up to 300 feet away from the measuring point with no effect on calibration and accuracy.

ALSO . . .

"BIKINI" CONTROLLER
Differential 0·5°C. Includes similar features to the Bikini Indicator. Send for specification sheet BIK. 1 and price list.

"BIKINI" INDICATOR/CONTROLLER
The Indicator can be supplied with an adjustable control contact for use with local or remote alarm or control relay.

Send for Specification Sheet BIK 2/NP and Price List.

Fielden

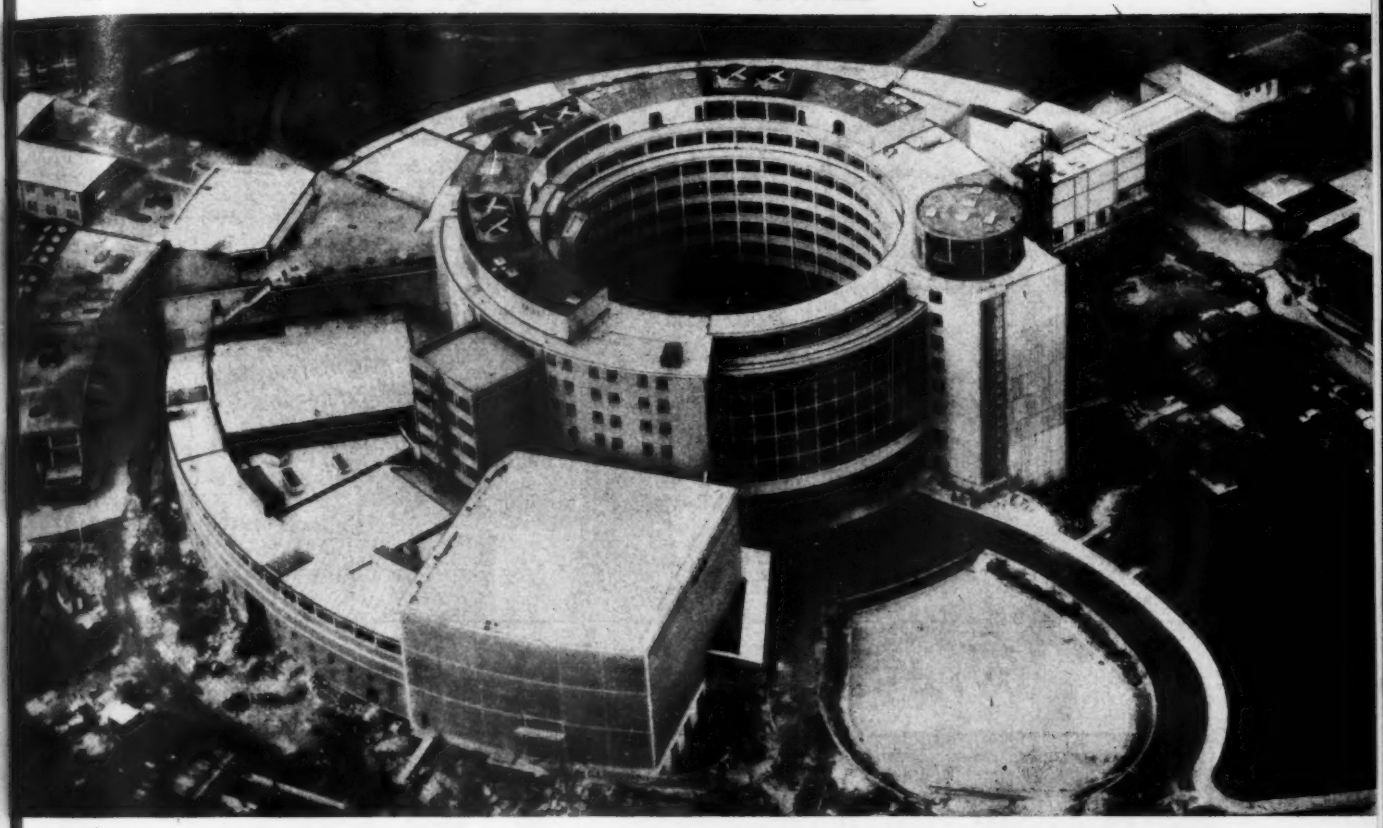
FIELDEN ELECTRONICS LTD · WYTHENSHAWE · MANCHESTER Phone: Wythenshawe 3251 (4 lines) Grams: Humidity Manchester
ALSO AUSTRALIA, ITALY AND CANADA *Branch Offices:* LONDON, WALSALL, STOCKTON-ON-TEES, EDINBURGH (A. R. BOLTON LTD) AND DUBLIN.
Agents throughout the world

Indicating Recording Control

B3

UNISTRUT

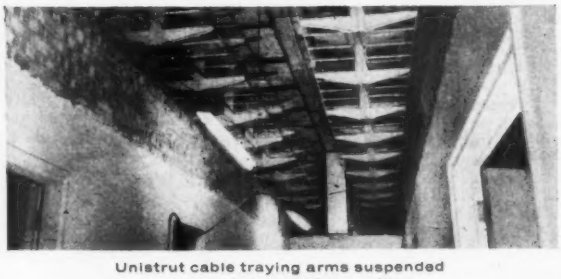
AT THE BBC WOOD LANE TELEVISION CENTRE



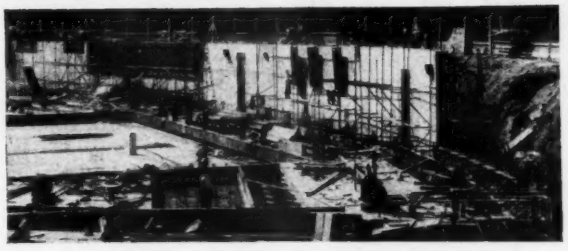
In a building which through its circular form presented a number of installation problems, a new type of Unistrut cable traying arm and the familiar concrete insert (over 3 miles of which have been used throughout the buildings) provide further examples of the versatility of Unistrut.
The traying arms support many miles of coaxial cable carrying sound and vision signals from the nine studios within the centre and from outside sources including Eurovision. The cables descend at frequent but irregular intervals, often in batteries of 400 at a time, to the various equipment bays.

MAXIMUM EASE OF ACCESS

The new Unistrut cable traying arms allow closer spacing with greater ease of access than standard arms previously available, and are suspended from the building structure using standard Unistrut channel and self-locating nut assembly for speed and rigidity.



Unistrut cable traying arms suspended on Unistrut channel from ceiling.



The 250 yd. ring duct under construction. Unistrut concrete inserts were built in at this stage.

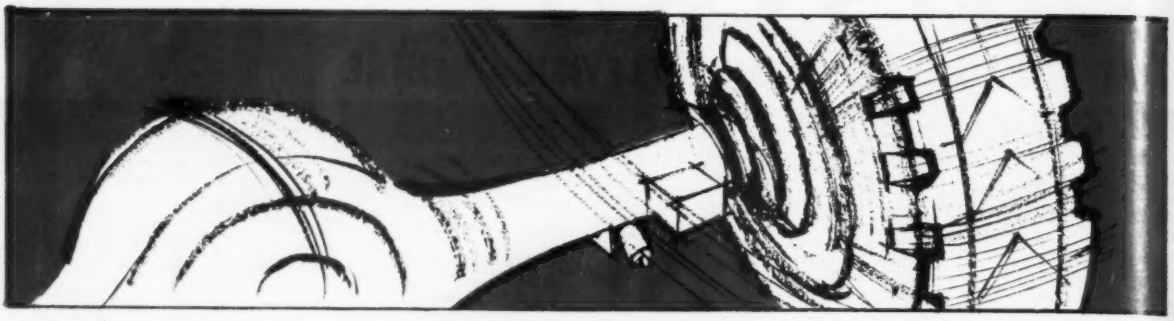
RING DUCT WITH CONCRETE INSERTS

Main services are carried below the building in a ring duct approximately 250 yards long with Unistrut concrete inserts embedded, at 2 ft. centres, during the pouring of the concrete. This eliminated the need to pierce for the thousands of fixings required; the cables resting on Unistrut components bolted directly into the inserts—again using the rapid, easily-aligned self-locating nut assembly. The inserts are able to carry a total U.D.L. of about 800 tons, thus limiting the cost of any future expansion required.

UNISTRUT FOR ALL SUPPORT PROBLEMS

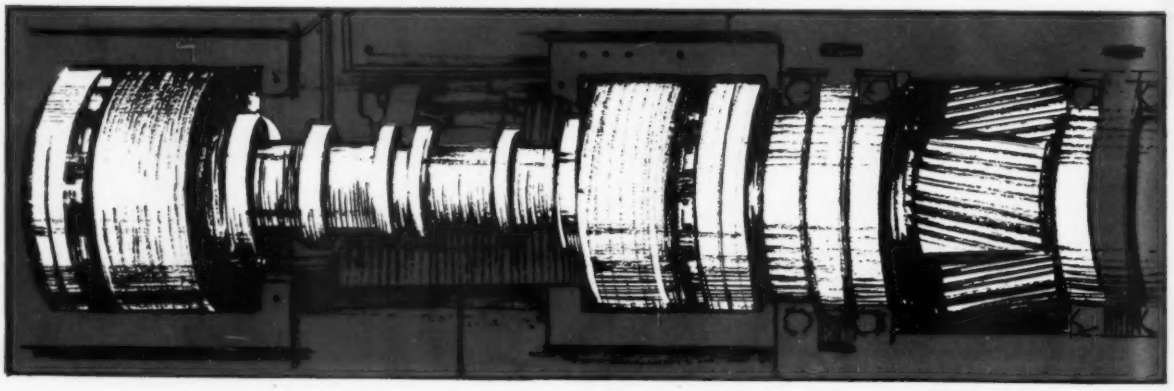
For information on the Unistrut system in relation to all support and framing problems—from pipe and cable running to the erection of partitions and even complete buildings, please write to the address below.

GKN UNISTRUT DIVISION OF SANKEY-SHELDON LTD. *43/45, Broadwater Road, Welwyn Garden City, Herts.*
Telephone: Welwyn Garden City 6321 (4 lines)



consult R&M bearing experts

when at the prototype stage



As machines grow more complex and performances increase, the selection of bearings becomes more difficult. It requires specialist knowledge.

In increasing numbers, design and development groups are consulting the Technical Department of Ransome & Marles for guidance. Specification as well as supply is part of the R&M service to the engineering industry.

Every enquiry gets equally impartial and confidential consideration. Every project benefits.

Ransome & Marles produce ball and roller bearings for most applications.

Publication 37 is a comprehensive guide to the full range.

BALL & ROLLER R&M BEARINGS

RANSOME & MARLES BEARING COMPANY LIMITED

NEWARK-ON-TRENT · TELEPHONE 456 · TELEX 37-626 · Branches, offices and agencies throughout the world

thousands of applications PROVE the

LANGALLOY-DURCO type 'F'

PLUG

VALVE

gives long trouble-free service in handling severe corrosives in almost any conditions. The stationary P.T.F.E. sleeve between the plug and the body is resistant to virtually all chemicals, provides an excellent sealing medium and has a very low co-efficient of friction. This exceptional feature, combined with the Langley quality inherent in the construction provides outstanding advantages:-

NO

CONTAMINATION OF FLUID IN THE LINE

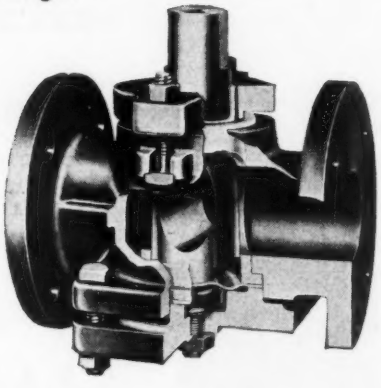
STICKING

POCKETS WHERE SOLIDS CAN COLLECT

NEED FOR FREQUENT SERVICE ON SITE

METAL-TO-METAL WEAR

PROBLEMS IN MAINTENANCE



VALVE DIVISION

LANGLEY ALLOYS LIMITED

LANGLEY · SLOUGH · BUCKS

Telephone: Langley 432 (7 lines) Telegrams & Cables: LANGALLOY Slough

PERSTA-Valves for nuclear service

Full line of Forged Steel
PERSTA-Valves up to 14″

- **simple design**
- **accurate workmanship and finish**
- **controlled material quality**

PERSTA

STAHL-ARMATUREN
SIEPMANN GMBH · KG · BELECKE/MÖHNE
GERMANY

PERSTA reliable in operation · PERSTA reliable in operation · PERSTA reliable in operation · PERSTA

EKCO Thermocouple Trip Amplifier

SPECIFICATION

Operational Trip Setting. 0-600°C.

Trip Margin Meter Indication. 50°C. below trip.

'Low-Margin' Trip. May be set anywhere within the available trip margin range.

Trip-Accuracy. 0.4% of trip temperature.

'Low-Margin' Trip Accuracy. Better than 2% of the meter range. (Accuracy limited because the meter is used for setting).

Hysteresis and Stability of Both Trips. 2% of meter range.

External Facilities. The warning and trip relays each provide the following facilities which are connected to plugs at the rear of the instrument:—two sets of change-over contacts and two short circuit pairs.

Input Signal Required. 40 μV/°C.

Thermocouple Earthing. Can be at either terminal or at the hot point. (The amplifier is isolated from earth).

Stability. Cold junction compensation ensures that performance remains within the limits specified up to 40°C. ambient temperature. Performance is unaffected by mains variations of +8% —20%.

Thermocouple Resistance. Up to 250 ohms for performance specified. Up to 500 ohms for ambient temperature ('cold junction') up to 30°C.

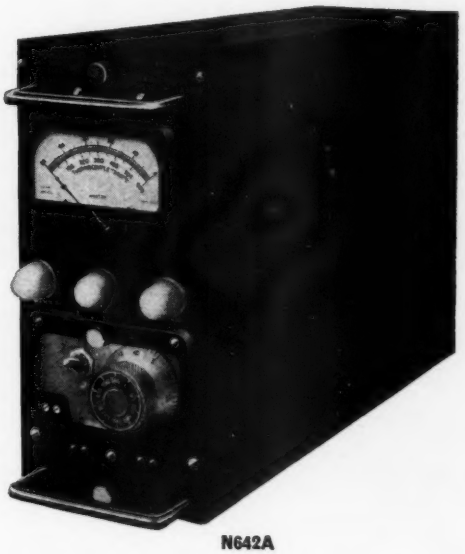
Response Time. Less than 0.2 seconds.

Recorder Output. A 100 mV recorder can be driven to indicate the meter reading at an impedance of 100 ohms.

Dimensions. Front panel 4″ wide x 8¾″ high. Depth 13″.

Mains Input. 110-120v or 200-250v A.C., 45/60 c/s.

Mains Consumption. 20 watts approximately.



N642A

The Ekco range of reactor instruments also includes the following:—

Reactor Period Meters with alternative ranges.
Reactor Power Error Meter.
Resistance Thermometer Trip Unit.
Shut-Down Amplifier (with start-up facilities and shut-down state trip).
Fast Neutron Monitor (installed).
Misalignment Indicator (for coarse control arms.)
Leak Indicator (for external heavy water leak).
Effluent Monitor.
Battery Box Assemblies.
Logarithmic Gamma Health Monitor (installed).
Slow Neutron Survey Meter (portable).
Beta-gamma Survey Meters (portable).
Decade Voltage and Current Generator (general purpose test unit).
Reactor Period Meter Test Unit.

EKCO ELECTRONICS LIMITED

Sales Dept., Southend-on-Sea, Essex. *Telephone:* Southend 49491

Installation & Service Dept., Ekco Electronics Works, Rochford, Essex. (Rochford 56866)

AMF-built open pool 5mw reactor operates 'round the clock

Safety · Maximum Experimental Flexibility
Potential Power Increase

The world's most powerful, privately-owned open pool research reactor has been operated continuously for over 7,000 hours at 5,000KW. The reactor is already on a 24 hour per day basis, dictated by the increasing work load.

Designed and built by American Machine & Foundry Company for Industrial Reactor Laboratories, Inc., this outstanding installation represents a tremendous advance in the development of nuclear reactors for research.

Significantly, it has disproved the theories of some authorities in the industry who were concerned that an open pool type reactor with a power level of 5 megawatts could not be operated successfully *and safely*. Operating data on the IRL reactor, in fact, indicates no limitations inherent in the design of the system which would preclude further increases in the power level up to the *10 megawatt range*.

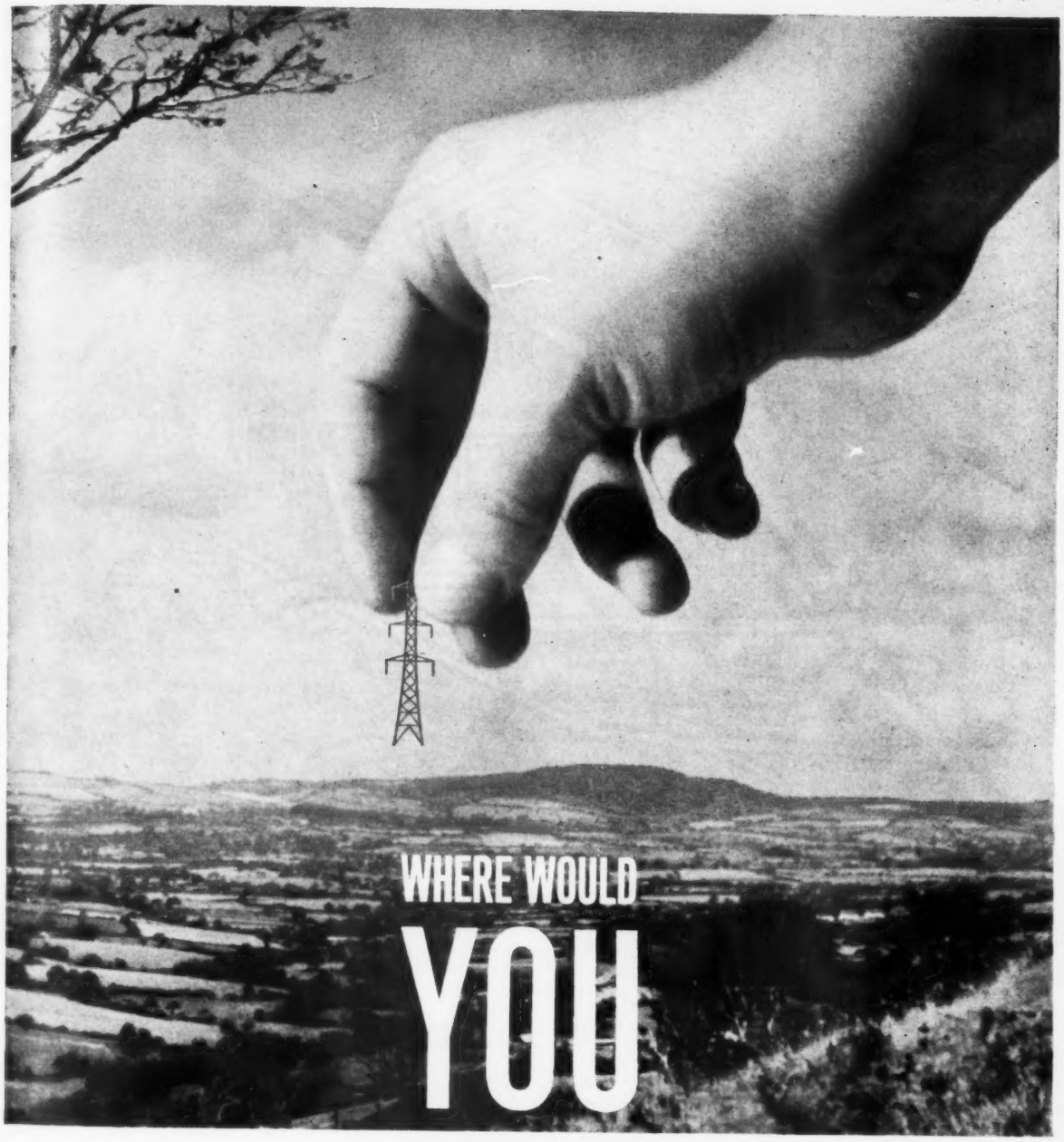
This power potential, combined with unequalled experimental flexibility, operational convenience, safety factor and the low cost of the open pool design, make this AMF reactor a truly outstanding nuclear research tool.

AMF

American Machine & Foundry Company

International Group • AMF Building • 261 Madison Avenue • New York 16, N. Y.

Overseas Plants and Offices: BOLOGNA • CARACAS • GENEVA • LONDON • MEXICO CITY • SÃO PAULO • STOCKHOLM • SYDNEY • TOKYO



RUN THE PYLONS?

They still live by lamp-light up in the hills. Soon, a new transmission line will thread its way along the valley, bringing the people up on the hill the electricity they've been wanting.

Pylons down here will mean a better life up there. But how will the people of the valley feel about the pylons? And the people who visit the valley?

The Central Electricity Generating Board are just as concerned about this as they are about bringing in the power. For the nation has charged the Board with a double duty. Not only to maintain an efficient, economical electricity supply, but also to preserve the amenities of the country as they go.

Often, these duties conflict. Again and again problems arise which seem impossible to solve. But always, they seek to achieve a balance. A balance between the need to answer demands for more power and the need to preserve the beauty, the intangible values, of a landscape, a village, the still unspoilt approaches to a town.

■ These advertisements are appearing in the farming and country magazines. The Central Electricity Generating Board thank contractors for their co-operation in the past, and know that they will do all they can, while engaged on work for the Board, to preserve amenities.

THE CENTRAL ELECTRICITY GENERATING BOARD

CEGB

AI's extensive field laboratory is located in California's Santa Susana Mountains. *Woodcut by Edward Kysar.*

How can A.I. facilities help you plan a Nuclear Program?

In the picturesque Santa Susana mountains near Los Angeles, Atomics International has built an extensive field laboratory for research, engineering and testing in the nuclear sciences. Here, and at a headquarters complex in the valley below, men who pioneered the creative uses of atomic energy are applying their experience to develop advanced nuclear reactors and associated equipment.

Fourteen years of experience in developing various types of reactors for the Atomic Energy Commission and other organizations have given the men of Atomics International a collective background unparalleled in the industry. The facilities at their disposal are among the most sophisticated and extensive in the world.

Results of AI's work have been demonstrated in projects for the AEC which include the Organic Moderated Reactor Experiment at the National Reactor Testing Station in Idaho and the Sodium Reactor Experiment at the company's field laboratory. Additionally, AI built and is operating SNAP II, a 220 pound prototype reactor to produce three kilowatts of electricity for space vehicles.

Atomics International is also building large power reactors for electric utilities in Ohio and Nebraska under AEC programs. Studies are underway for other power reactors in the United States and Europe. Research reactors have been built by AI for Denmark, Germany, Italy, Japan, Puerto Rico and several sites in the United States.

For details contact: ATOMICS INTERNATIONAL, Canoga Park, California, U.S.A. Cable address: ATOMICS.

ATOMICS INTERNATIONAL
A DIVISION OF NORTH AMERICAN AVIATION, INC.
PIONEERS IN THE CREATIVE USE OF THE ATOM

Other offices in: Washington, D.C., U.S.A.; Geneva, Switzerland. Affiliated with: INTERATOM, Bensberg/Cologne, Federal Republic of Germany and DYNATOM, Paris, France.

Trawsfynydd contract crowns five years' research

Esso to lubricate world's latest atomic power station

Intense research develops lubricants that resist radiation, high temperatures, and gas contamination for years.

Under radiation, normal oils turn into a sticky mess and ordinary grease starts to break down. The carbon-dioxide gas circulating in the reactor modifies the structure of the grease even further. Both lubricants break down completely in the intense heat surrounding a nuclear furnace. On top of all this, once the reactor has started up, the equipment in and around it cannot be re-lubricated for several years.

Now, after five and a half years' research, a team from the Abingdon Laboratories of Esso Research Ltd., has provided the answer.

Working closely with the scientists and engineers of the Central Electricity Generating Board's Atomic Power Division and the five consortia tendering for the new nuclear power station at Trawsfynydd, in Snowdonia, this team has developed a new range of lubricants, called Essotron oils and Cosmos greases, which are resistant to radiation, heat and gas.

And Esso have proved conclusively, in practical tests, that these lubricants will remain one hundred per cent reliable, even in the vital control machinery at Trawsfynydd, for the necessary length of time. As a result, the sole contract for the supply of all lubricants to Trawsfynydd, which will be one of the two biggest nuclear power stations in the world, has been awarded to Esso.

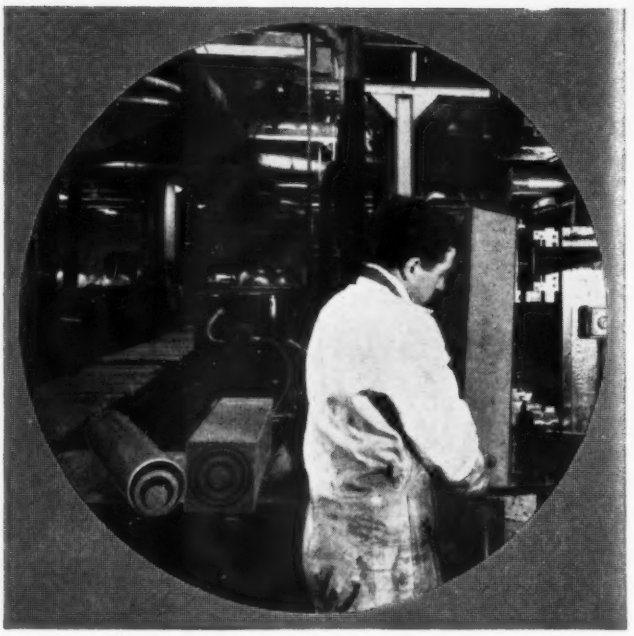
To the authorities concerned, however, this contract is much more than a reward for successful research. It is a means of ensuring that Esso's vast technical resources will always be available to study and meet the demands of the new reactor when it is in operation.

In other words, the C.E.G.B., the U.K.A.E.A. and Atomic Power Constructions Ltd., who have won the main Trawsfynydd contract, have proved, as hundreds of smaller organisations in less dramatic industries prove every year, that it pays not only to consult Esso, but to go on consulting them. If your firm has a lubrication problem this fact applies equally to you.

Esso INDUSTRIAL LUBRICANTS

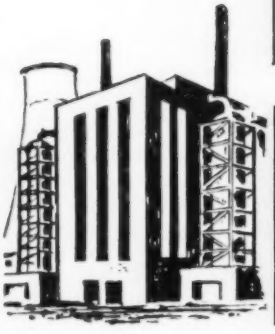
ESSO PETROLEUM COMPANY LIMITED · 36 QUEEN ANNE'S GATE · LONDON SW1

Circle **No 21** on reply card for further details



GRAPHITE MACHINING

Powell Duffryn Carbon Products Ltd.
are the official contractors
to the General Electric Company
for the machining of Nuclear Graphite.



THE POWELL DUFFRYN GROUP OF COMPANIES

POWELL DUFFRYN CARBON PRODUCTS LTD.,
NUCLEAR GRAPHITE DIVISION
Springfield Road, Hayes, Middlesex. Telephone Hayes 3994

Circle **No 22** on reply card for further details

Deux grandes marques de tubes en aciers spéciaux et inoxydables pour l'industrie atomique

VALLOUREC

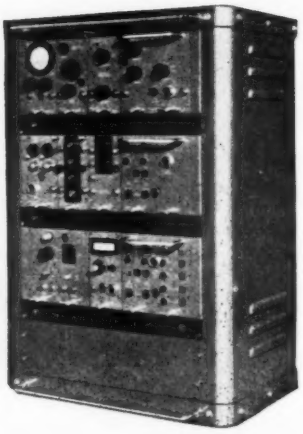
SOCIÉTÉ ANONYME AU CAPITAL DE 110.000.000 DE NOUVEAUX FRANCS

SIÈGE SOCIAL ET SERVICES COMMERCIAUX : 6, RUE DARU • PARIS (8e) • CAR. : 03-60, 05-00

UNITIZED NUCLEONIC RANGE

The plan behind this Type 200 equipment is to offer you a Unitized Range (already 24 units and still increasing) not only to cover every type of nucleonic counting, but one that can be added to at will, so that you get only what you want, when you want.

- **Suitable for all types of nucleonic detectors.**
- **Built to a stringent specification.**
- **Designed in conjunction with A.E.R.E. Harwell.**
- **Flexible in use—a unit for every purpose.**



Enquiries should be addressed to:—

INSTRUMENT DIVISION

HIGH CHURCH STREET · NEW BASFORD · NOTTINGHAM

ERICSSON

ERICSSON TELEPHONES LIMITED · HEAD OFFICE · 22 LINCOLN'S INN FIELDS LONDON W.C.2

MAINTAINING 'UNIT' QUALITY

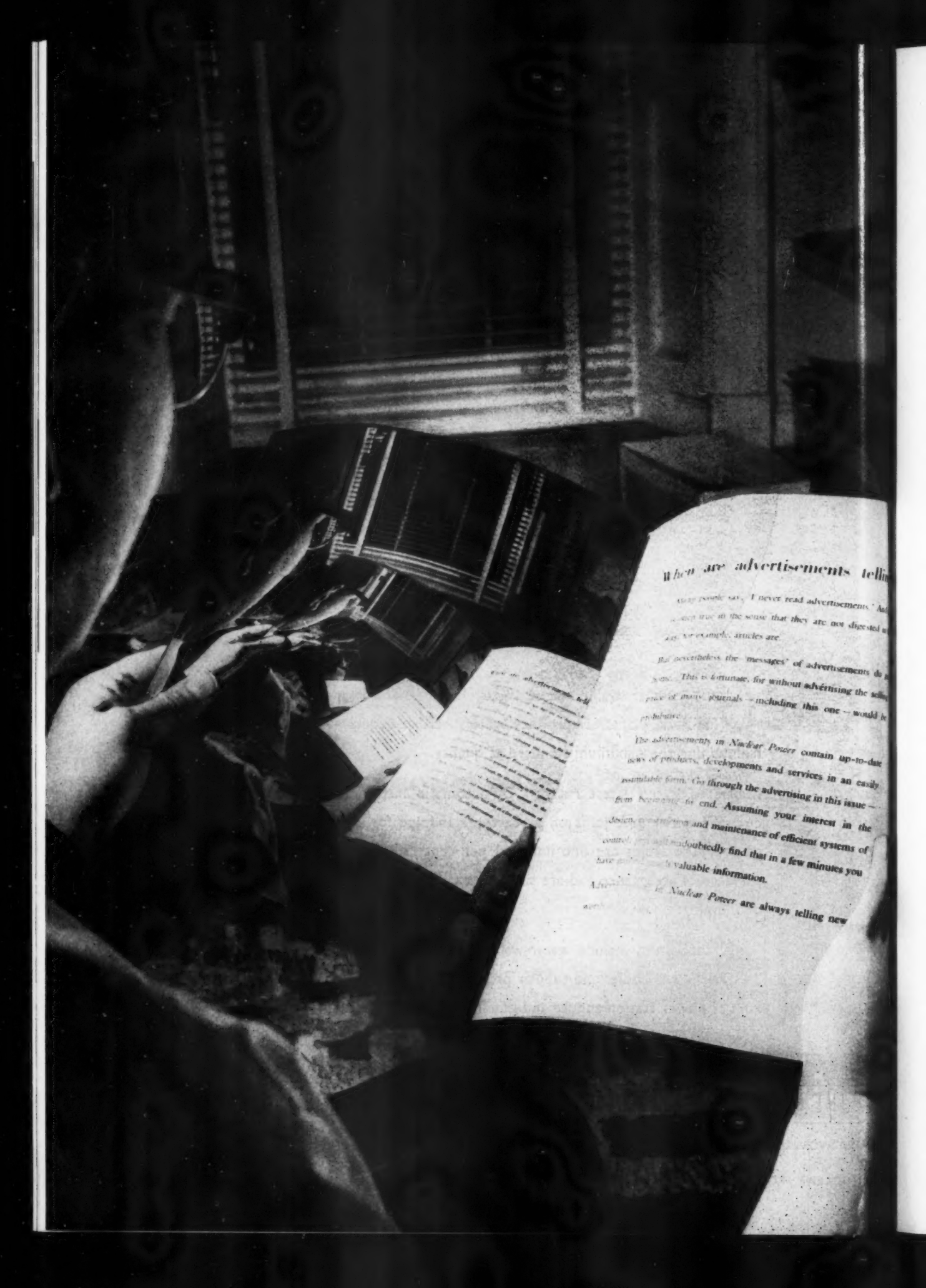
UNIT tubular welded fabrications, for high or low pressures for industrial plants, are produced with specialized equipment–thereby maintaining the maximum standard of quality.

Illustrated is our latest Fusarc CO_2 automatic installation welding a circumferential butt joint on a reactor standpipe for Bradwell power station. The welds are one hundred per cent radiographed to a high standard of acceptance and are subject to the survey of Lloyds Register of Shipping.

'Unit' specialities include water-wall headers, steam and oil receivers, de-superheater bodies and tubular products of all descriptions for every kind of power station and for industrial steam raising plants.

THE UNIT SUPERHEATER **UNIT** AND PIPE COMPANY LTD

UNIT WORKS, SWANSEA • *Telephone*: SWANSEA 54091 (*6 lines*) *Telegrams*: 'SUPERUNITS', SWANSEA • *Telex*: 4835


Why are advertisements telli
many people say, 'I never read advertisements.' And
even true in the sense that they are not digested w
as, for example, articles are.
Nevertheless the 'messages' of advertisements do
ions. This is fortunate, for without advertising the sellin
ence of many journals – including this one – would be
problematic.
The advertisements in Nuclear Power contain up-to-date
news of products, developments and services in an easily
assimilable form. Go through the advertising in this issue –
from beginning to end. Assuming your interest in the
design, construction and maintenance of efficient systems of
control
doubtedly find that in a few minutes you
valuable information.
Nuclear Power are always telling new

When are advertisements telling?

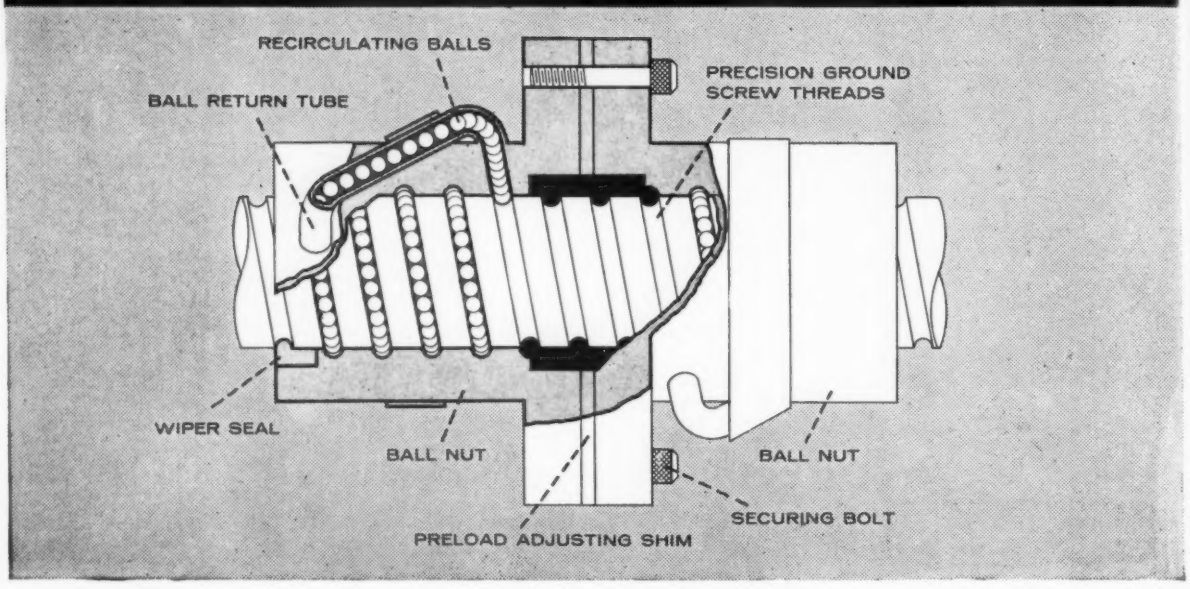
Many people say, 'I never read advertisements.' And this is often true in the sense that they are not digested in the way, for example, articles are.

But nevertheless the 'messages' of advertisements do get home. (This is fortunate, for without advertising the selling price of many journals — including this one — would be prohibitive.)

The advertisements in *Nuclear Power* contain up-to-date news of products, developments and services in an easily assimilable form. Go through the advertising in this issue—from beginning to end. Assuming your interest in the design, construction or maintenance of any of the numerous types of equipment used in the atomic energy field—from the simplest to the most complex—you will undoubtedly find that in a few minutes you have gained much valuable information.

Advertisements in *Nuclear Power* are always telling news worth being told.

Beaver pre-loaded ball screws, up to 95% efficient, operate at -52°C to over 400°C with no backlash...



...ANOTHER ENGINEERING ADVANCE FROM BRISTOL SIDDELEY

Bristol Siddeley Engines Limited produce Beaver* pre-loaded ball screws. These ball screws achieve a minimum efficiency of 90% and they can operate within a temperature range of −52° C to 400° C without lubrication, and up to 170° C when lubricated.

Machined and ground to the highest standards of precision engineering Beaver pre-loaded ball screws greatly increase transmission efficiency. They reduce the power required for actuation by as much as 80%, when converting rotary drive into linear output or force input into torque output. By eliminating backlash, with pre-loading, they give precise control over very small increments of motion and a high response frequency. And when compared to conventional screw mechanisms, they provide a predictable operating life which is much longer, require much less maintenance and give more trouble-free operation.

Basic design application analysis

Bristol Siddeley engineers make an exhaustive analysis of each specification. And each unit is specially designed for its particular application. Beaver ball screws are made automatically reversible or with controlled "no-back," with multiple or single circuits. Beaver pre-loaded ball screws have been proved as the most efficient method of converting rotary into linear thrust in over 2,700 engineering applications in many branches of industry. They have been designed already with rated operating load capacities of 370,000 lb (825,000 lb maximum static load) but the maximum potential operating load is, in most cases, limited only by the requirement.

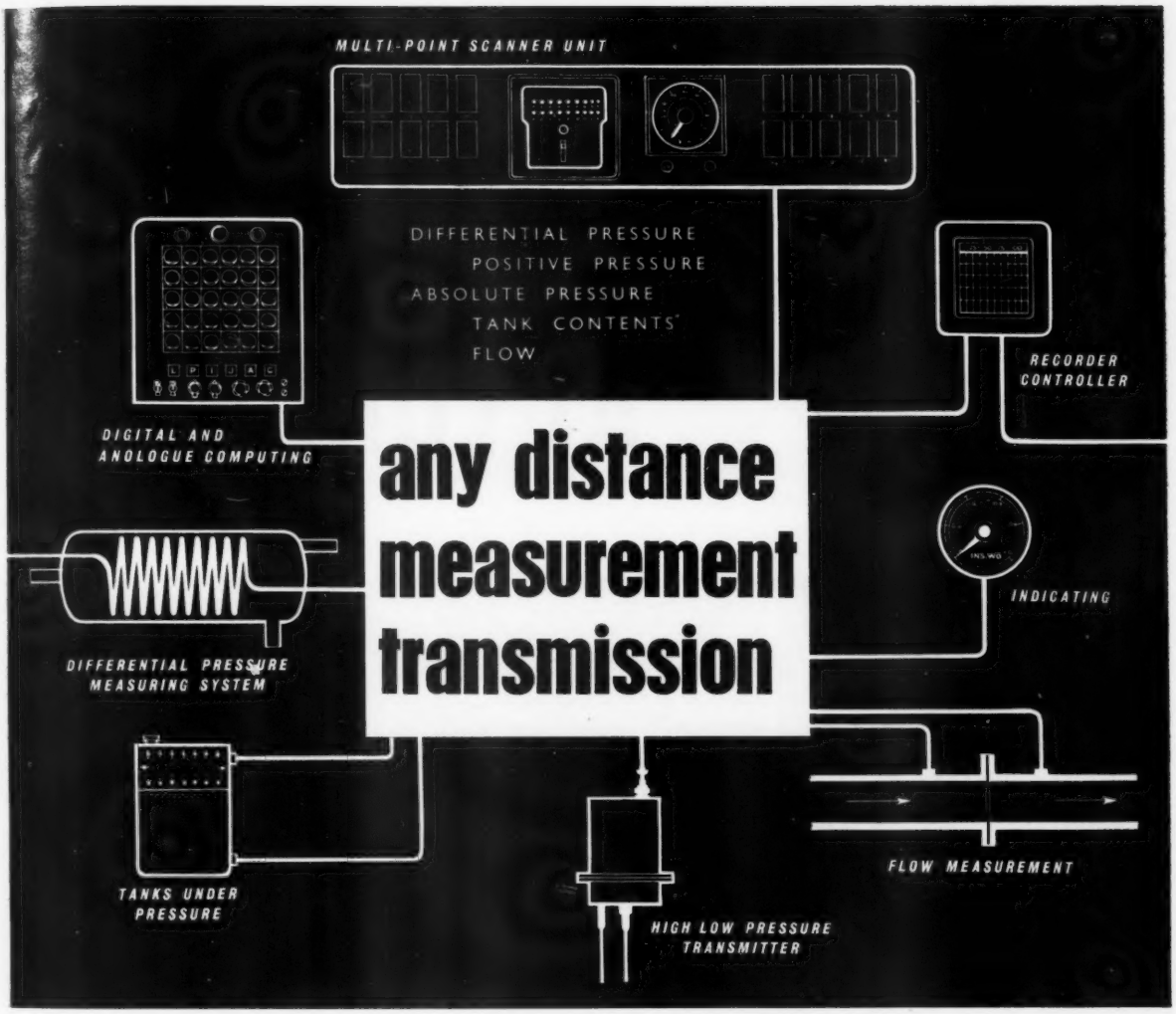
Bristol Siddeley Beaver ball splines have been developed to eliminate the disadvantages of conventional splines. The designs are very effective in minimising friction, particularly when high torsional and bending loads are imposed during linear movement.

** Complete technical and manufacturing co-operation with Beaver Precision Products Inc., Detroit.*

For further information please write to J. B. Starky, Sales Manager (Beaver Products Division), Bristol Siddeley Engines Limited, PO Box 17, Coventry, England.

BRISTOL SIDDELEY ENGINES LIMITED

Circle **No 28** on reply card for further details



FEATURES OF THE 'REDIFF' PRESSURE GAUGE

- ★ Measurements from 0 to 1 inch of water gauge full scale deflection.
- ★ High Static Pressures Gradually or Instantaneously.
- ★ Instantaneous High Static Overload.
- ★ Usable with liquids/gases having radio-active constituents.
- ★ Models made of Monel available.
- ★ Capable of withstanding sudden pressures up to 4000 p.s.i. and temperature up to 250°C.
- ★ Electrical Supply : 100–200–220–240 v, 50 or 60 c/s.

Ask for details of the 'Rediff' Instrument from:

A P P L E B Y & I R E L A N D L T D

Basingstoke Hampshire England

Tel : Basingstoke 2510/3 Telex : 8546

Circle **No 29** on reply card for further details

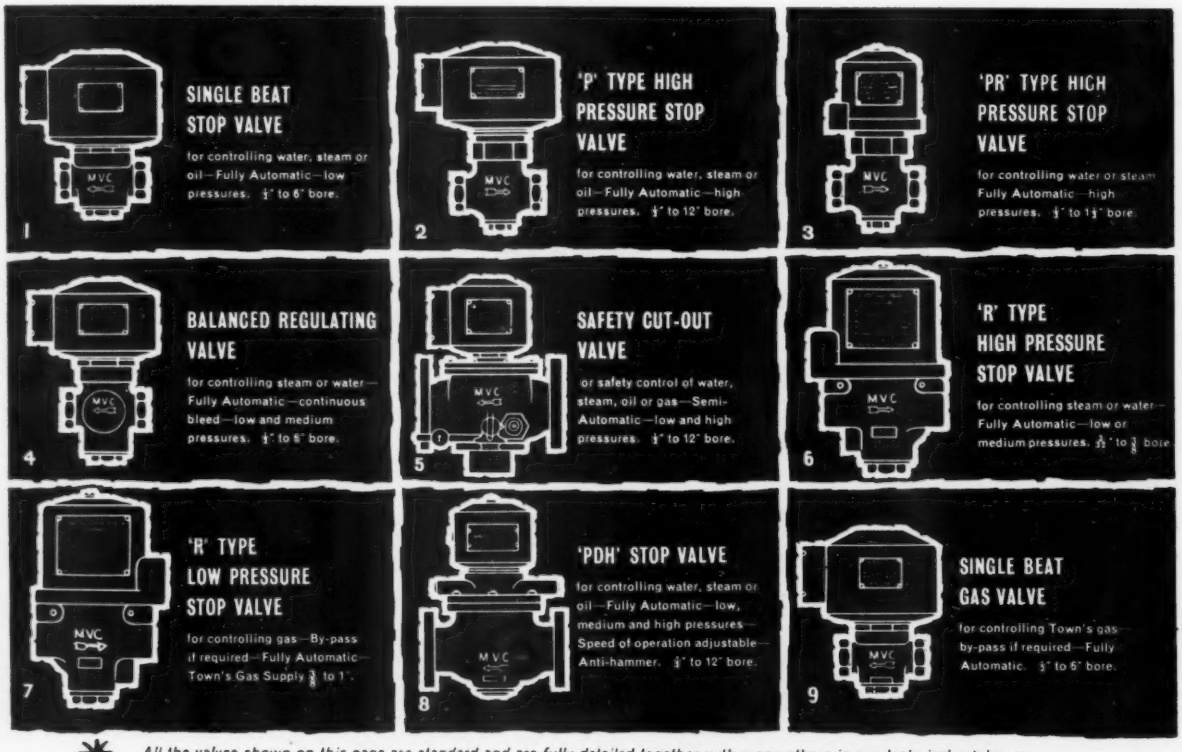
WE OFTEN TALK 'SHOP' AT LUNCH

MVC THE MAGNETIC

MVC Is the Registered Trade Mark of the Magnetic Valve Co. Ltd.

(Because we like to thoroughly digest our customer's problems!)

We like to see a job well done. And we like to see our customers happy!
Getting our teeth deeply embedded in to our customers' problems—no matter how specialised and individual—is the backbone of the MVC Service!
Over 30 years' experience and 'know-how' has been built-in to our range of over 100 automatic control valves. People control water with them, gas with them, oil with them, steam with them and a host of other industrial liquids and gases too! Mushrooms are grown with them, jam is made with them and ships' cargoes are frozen with them!
You'll find that expert consultation and advice cost you absolutely nothing at MVC. Our full experience is at your disposal. Many times, what has first appeared to be impossible has been achieved. Why not write *now* for our new comprehensive catalogue No. 41 which contains full details of our complete range!


1
SINGLE BEAT STOP VALVE
for controlling water, steam or oil—Fully Automatic—low pressures. ¼" to 6" bore.
2
'P' TYPE HIGH PRESSURE STOP VALVE
for controlling water, steam or oil—Fully Automatic—high pressures. ¼" to 12" bore.
3
'PR' TYPE HIGH PRESSURE STOP VALVE
for controlling water or steam Fully Automatic—high pressures. ¼" to 1¼" bore.
4
BALANCED REGULATING VALVE
for controlling steam or water—Fully Automatic—continuous bleed—low and medium pressures. ¼" to 6" bore.
5
SAFETY CUT-OUT VALVE
or safety control of water, steam, oil or gas—Semi-Automatic—low and high pressures. ¼" to 12" bore.
6
'R' TYPE HIGH PRESSURE STOP VALVE
for controlling steam or water—Fully Automatic—low or medium pressures. ¼" to ⅜ bore
7
'R' TYPE LOW PRESSURE STOP VALVE
for controlling gas—By-pass if required—Fully Automatic—Town's Gas Supply ⅜ to 1".
8
'PDH' STOP VALVE
for controlling water, steam or oil—Fully Automatic—low, medium and high pressures—Speed of operation adjustable—Anti-hammer. ¼" to 12" bore.
9
SINGLE BEAT GAS VALVE
for controlling Town's gas by-pass if required—Fully Automatic. ¼" to 6" bore.

All the valves shown on this page are standard and are fully detailed together with many others in our technical catalogue.

VALVE CO. LIMITED

7 KENDALL PLACE · BAKER STREET · LONDON · W.1. TEL: HUNTER 1801 (4 LINES)

WHEN ALL IS SAID AND DONE, EVERY REACTOR DEPENDS UPON ITS FUEL ELEMENTS...

DRAGON and other High Temperature reactors pose more than usually difficult problems in this respect, in that few canning materials can meet the triple requirement for strength at high temperature, small appetite for neutrons and impermeability to fission gases.

GRAPHITE, with its high temperature capabilities, goes far to meet these needs, but in its usual form it is too permeable to the passage of fission gases at the temperature concerned.

HAWKER SIDDELEY, in collaboration with DRAGON, U.K.A.E.A. and R.A.E. Farnborough, have now developed an impregnation process which has resulted in large reductions in permeability, even at the high temperatures involved in DRAGON.

Today's nuclear developments are tomorrow's industrial necessities.

HAWKER SIDDELEY IMPERMEABLE GRAPHITE FOR
Bursting Discs · Chemical Plant · Crucibles · Electrodes
Gland Seatings · Heat Exchangers · High Temperature
Bearings and Bushes · Hot Pressing Dies · Nuclear Fuel Cans
Rocket Nozzles · Sealing Rings · Vacuum Furnace Linings.

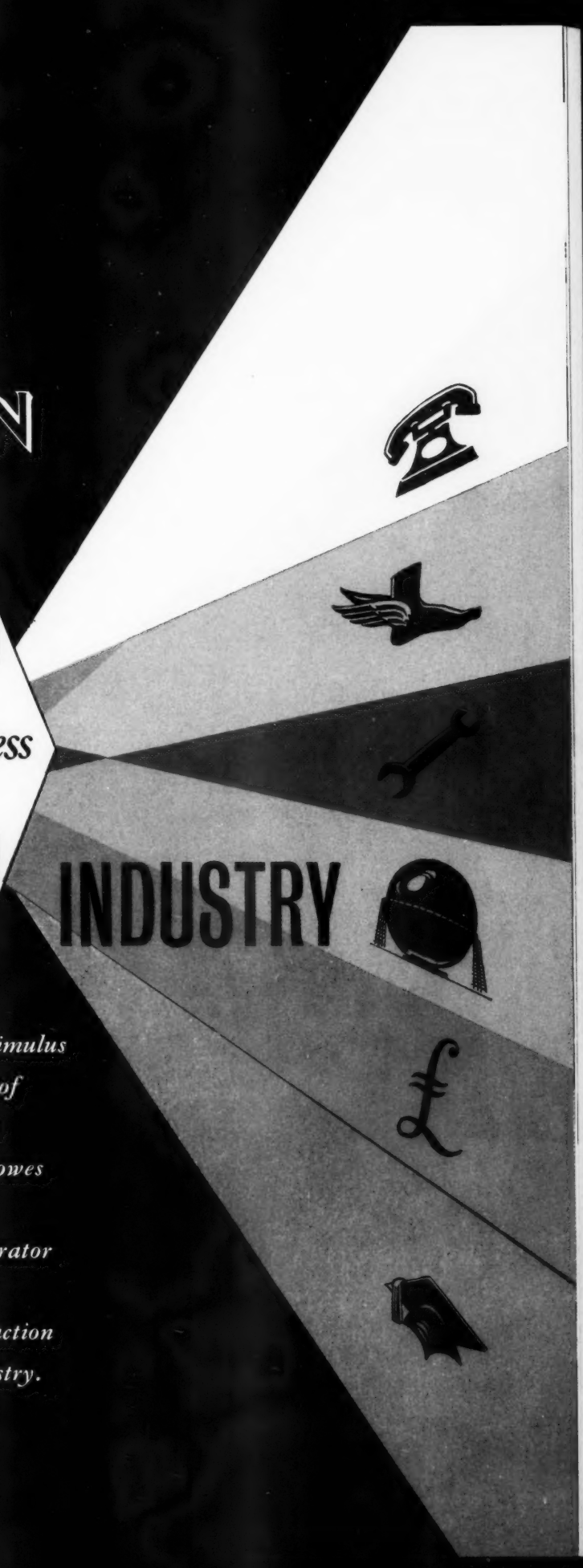
THE HEART OF THE DRAGON

HAWKER SIDDELEY NUCLEAR POWER CO. LTD.
SUTTON LANE. LANGLEY, ENGLAND. TEL: SLOUGH 24451. TELEGRAMS: NUCLEPOWER SLOUGH

SOLARTRON

common stimulus to progress

IN EVERY INDUSTRY



Overleaf we show, in easy reference form, the stimulus which Solartron is giving to every field of human endeavour today. This can only be a brief outline—but the responsible businessman owes it to himself to be well-informed on the exciting potential of electronics, the accelerator of progress. Each step forward in electronic technique or application sparks off a chain reaction of inventiveness and progress in every industry.

SOLARTRON

Learn here how Solartron is accelerating progress, cutting costs and solving problems in your field!

	INSTRUMENTS	COMPUTERS
	A complete range of precision measuring instruments, oscilloscopes for every application; dynamic analysis equipment; digital display instruments and both conventional and transistorised power supplies.	*Advanced modular construction 'Space' series computers ranging from the S—amplifier Analogue Tutor, through 'Minispace' and 'Space 30' to 'Space 60', 90'—and larger special-purpose machines.*
COMMUNICATIONS	**Telecommunications** **Radio** **Television** **Facsimile** **Teleprinting** **Radar & Sonar**	Line and radio link power measurement; a.f., and r.f. amplifier testing; precise calibration; vectorial measurement and oscillographic, metered or digital display; microwave test and power supply instrumentation.	Synthesis and evaluation of networks; repetitive test of simulated systems under programmed conditions; design evaluation of overhead transmission equipment; solution of dynamic traffic loading problems.
AUTOMOTIVE & TRANSPORT	**Aviation** **Railways** **Shipping** **Roads** **Spacecraft**	Vibration analysis and display; evaluation of aircraft and automotive servo systems; testing of mobile electronic equipment; design and development of power controls, instrumentation of research vehicles and guided weapons.	Servo system, suspension and power transfer system simulation and evaluation. Solution of aerodynamic, hydrodynamic and allied linear and non-linear problems of advanced nature. Investigation of fuel or gas flow and throttling in jet and turbine engines.
MATERIALS & MANUFACTURE	**Raw Materials** **Chemicals** **Minerals** **Mass Production** **Iron & Steel** **Textiles** **Food & Drink**	Full range of precision electronic instruments for all aspects of measurement in industrial research, development and production test. Choice of high-accuracy meter, oscilloscope or digital display presentation.	Process control simulation and analysis, analogue synthesis of all types of controlled power-driven equipment—paper, textile, belt movement, etc. Chemical plant and refinery design, dynamic evaluation of complex problems.
POWER	**Nuclear** **Water** **Electricity** **Gas** **Steam** **Solar** **IC Engine** **Gas Turbine**	Instrumentation for supply testing and visual display. Stabilised conversion (AC-DC), and battery replacement (transistorised) bench units and sub-units. Vectorial measurement and analysis equipment. Test instruments for gyros, synchros, and servo-mechanisms.	Simulation of nuclear reactor controllers and basic reaction processes. Investigation of reactor thermodynamics and kinetics. Determination of critical and runaway conditions. Synthesis of power transmission networks.
COMMERCE	**Insurance** **Banking** **Credit Control** **Stock Control** **Warehousing** **Packaging** **Retailing**		Derivation of future national and international business trends by analogue simulation based on known information and laws of economic inter-relationship.
RESEARCH & EDUCATION	**Services** **Technical Training & Education** **Schools & Universities** **Institutions** **Public Authorities** **Hospitals & Medical Science**	For use in technical colleges and universities—oscilloscopes, measuring instruments and power supplies of highest quality. Reliable, ruggedly constructed, functionally designed and utilising the most up-to-date design techniques.	Simple computers, designed specifically for training purposes, solution of differential equations and basic dynamic problems, invaluable also for training operators of larger analogue machines.

DATA HANDLING

Precision, ultra-high temperature pressure transducers; data logging, conversion, display and high-speed print-out equipment; industrial multi-channel magnetic tape recorder/reproducer systems.

Transducers used by Bristol Aircraft in developing T.188

Data logging from test rigs of multiple variable parameters; high accuracy magnetic recording of local or telemetered data from aircraft or missiles; strain and pressure measurement instrumentation; high-speed digital recording from test rigs and prototypes.

Precise measurement of pressures under exceptional conditions. Monitoring, logging and analogue or digital recording of process data for every industry. Programmed control of plant and processes by magnetic tape and associated error-sensing equipment.

Continuous monitoring of supplies—electricity, water, gas, compressed air, etc. Digital logging for permanent record, digital display for remote supervision and control. Precise pressure measurement under extreme conditions.

DATATAPE

OSCILLOSCOPES

RADAR Simulation

Training, tactical and special-purpose evaluatory radar simulators having the highest degree of display authenticity. For advanced training in, and appreciation of, military, naval, A.T.C., or marine navigation radars.

Air traffic control training and evaluation of new systems, training of air force, naval and merchant marine radar operators and controllers. Tactical training in manoeuvre or combat-air, sea, or combined operations.

RADAR SIMULATOR

CYBERNETICS

Simulation means more concentrated training, more effective training—in radar appreciation, for control, navigation or defence. Simulated radar data can be fed to early warning systems to give vital recognition practice and heighten awareness under emergency conditions.

BUSINESS Machines

ERA, Electronic Reading Automaton, reading business information directly from original documents. Cybernetic-principle machines for accelerated training in manual co-ordination processes.

Accelerated training of morse, teleprinter, Teletypesetter and other operators by cybernetic training machines. High-speed recognition of printed data for transmission serially in any form over existing telecommunication or radio links.

Reading of p.s.v. ticket tally rolls for central data processing, providing traffic analyses and cash return information to operators in a fraction of the time previously required.

E.R.A.

High-speed reading of tally rolls from public utility meter readers —gas, electricity, water. Provides more immediate and concentrated record for accounts and control needs, direct input information for computer assimilation.

High-speed serial reading of printed or typewritten characters for computer input use. In banks, insurance companies, Co-ops., Govt. departments, public utilities and all large organizations handling continuous-feed or separate document information sources.

Training for complex muscle-eye co-ordination tasks achieved immeasurably more quickly and effectively than by human instruction. Unsuitable pupils quickly assessed thus improving training economy factor.

AUTOMATION & Process Control

X-Ray Spectrometer—for continuous, accurate non-destructive analysis; Electronic Checkweigher for precise packaging control; programmed actuators; automatic warehousing order-filling equipment.

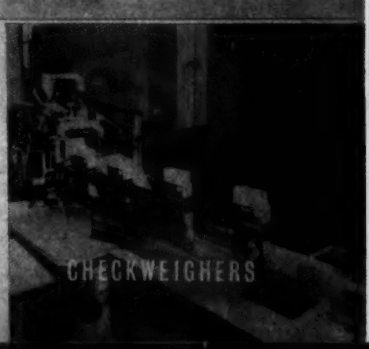
X-RAY SPECTROMETER

Control of transport fleet overhaul schedules by routine spectrometric analysis of IC engine oil, thus assessing accurately the wear of bores and bearings.

Continuous analysis and control by X-ray spectrometry down to Atomic No. 12—non-destructive, high-accuracy. High-speed electronic checkweighing of finished or cast parts integral with inspection processing.

SOLARTRON

High-speed electronic weighing of packaged foods, etc., at rates of up to two per second; automatic warehousing for institutional, wholesale or retail application—input demand renders listed items available inside fifteen seconds.



CHECKWEIGHERS

SYSTEMS CAPABILITY

...what SOLARTRON can do

It must be apparent from the pattern of the preceding pages that Solartron product lines are inter-related and complementary in application.

Continuous research and applications engineering in all these fields gives Solartron, now, a unique insight into present-day and future requirements of industry, resulting in a really soundly based *systems* capability—ability of the highest order to judge and advise in terms of tomorrow, to see the whole picture and do the whole job.

WHAT A 'SYSTEM' DOES

A 'system' is a purposive interconnection of electronic and other units, working together to solve a problem or to effect precise control in a specified way. Parts of an electronic system are concerned with measurement, others record, compute or compare. There may be—as in a controller which optimises a process—no visible output; or, for another application, measurements may be printed-out at a hundred a second. However the job is done, electronics gives you closer control, faster presentation of information, points up trends—gives timely warning of deviations. In the sphere of training, electronics is essentially impartial, flexible—a dozen blocks ahead of human teaching; for communicating information electronic techniques are instant and error-free. Learn how your industry can use electronics—ask Solartron.

CLOSING THE GAPS

Solartron, in addition to continuously programming expansion in the field of precision measurement and display, have repeatedly 'broken through' in research; in 'ERA', to clear the bottleneck at digital computer inputs; in 'SAKI', which uses advanced cybernetic principles to speed operator training—plus a host of advances in magnetic recording, analogue-to-digital conversion and very-low-frequency dynamic analysis. Tiny pick-offs which faithfully transmit intelligence under extreme conditions are in production at Farnborough by methods which give new meaning to the word precision. Radar simulators, automatic X-ray analysers, high-speed printers and a new generation of 'learning' machines too, are in production in this ultra modern manufacturing plant.

Whatever the skills and types of 'know-how' needed to find the best solution to a systems problem, benefit from continuous cross-fertilisation of ideas—talk to Solartron experts in O & M, data processing, mass manufacture and process control, automation, computing, simulation or training. Then let us advise you, whatever your industry, on the best solution to the measurement and control problems you see ahead.

enquiries should be addressed to THE SOLARTRON ELECTRONIC GROUP LIMITED

Victoria Road, Farnborough, Hampshire. Telephone: Farnborough (Hants) 3000

cut this out and send NOW

to the MAILING LISTS Supervisor

THE SOLARTRON ELECTRONIC GROUP LIMITED

45 Thames Street, Kingston-on-Thames, Surrey

I would like to receive future Solartron publications dealing with the subjects I have ticked opposite.

Name .....

Position Held .....

Company *(Name and Address)* .....

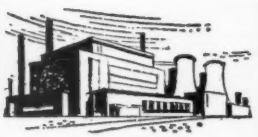
.....

.....

Instruments 1	Oscilloscopes 2	Power Supplies 3	Dynamic Analysis 4
Digital Recorders 5	Computers 6	Data Handling 7	Radar Simulators 8
Reactor Simulators 9	X-ray Spectrometers 10	Checkweighers 11	Automatic Warehousing 12
ERA 13	Cybernetics 14	Automation 15	Process Control 16

THERMAL INSULATION BY Newalls

Throughout the years Newalls have built an enviable reputation in the insulation of conventional power stations. This specialised experience is now being drawn upon on an ever growing scale in solving the complex problems of Nuclear Power Development. Recent contracts in this field reflecting Newalls supremacy are:—



HINKLEY
C.E.G.B. NUCLEAR POWER STATION

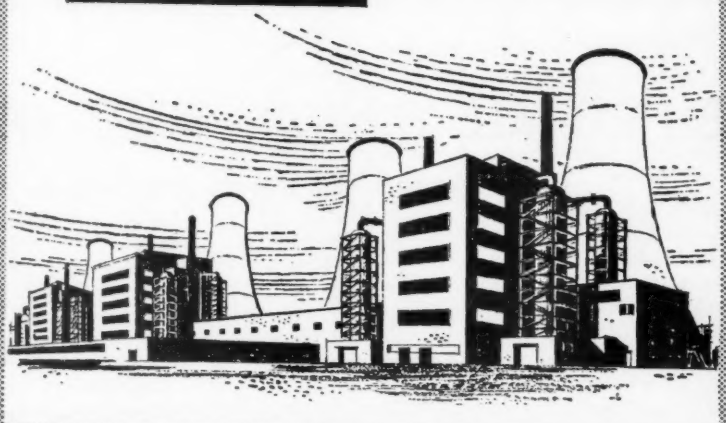
At Hinkley Point, Newalls have been entrusted with the insulation of the reactors, steam raising units, gas ducting, integral piping, etc., under contract to Babcock and Wilcox Ltd.

CHAPELCROSS
U.K.A.E.A. NUCLEAR POWER STATION

Under contract to Babcock and Wilcox Ltd., Newalls have carried out the insulation of the 16 steam raising units and integral piping. The insulation of turbines, blowers, associated auxiliary equipment and piping has been carried out under contract to C. A. Parsons and Co. Ltd.

BRADWELL
C.E.G.B. NUCLEAR POWER STATION

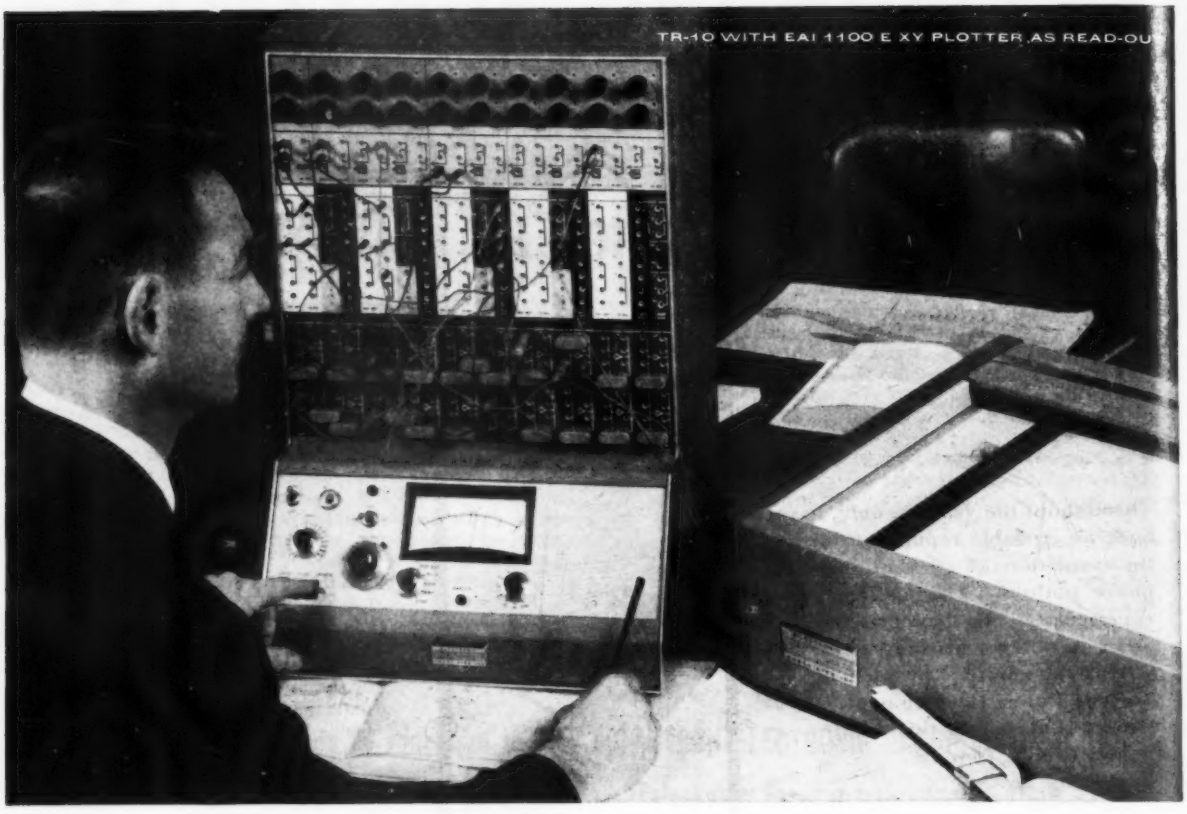
At Bradwell-on-Sea a further large contract for the thermal insulation of turbines, associated auxiliary equipment and piping (main and auxiliary turbine plants) has also been placed by C. A. Parsons and Co. Ltd. with Newalls.



NEWALLS INSULATION COMPANY LIMITED

Head Office: WASHINGTON, CO. DURHAM.
A member of the TURNER & NEWALL ORGANISATION.

Offices and Depots at: LONDON, GLASGOW, MANCHESTER, NEWCASTLE UPON TYNE, BIRMINGHAM, BELFAST, DUBLIN, BRISTOL and CARDIFF Agents and Vendors in most markets abroad.



PALMER

another "PACE" breakthrough

THE FIRST ALL TRANSISTORIZED ANALOG COMPUTER

basic model less than $4000 f.o.b. New York

This compact unit, 15" x 16" x 24" high, can provide day-in day-out instant solution of your most vexing engineering problems. Even if you have never seen a computer before, you can learn to operate the TR-10 as easily as you learned to use a slide rule.

Simply turn a dial to feed in design parameters, and the computer provides an instant by instant, dynamic picture of the effect of each change. You can study the inter-related effects of heat, pressure, flow, vibration, torque or any variable, and visually compare one with the other. Engineering data comes alive-insight into how new designs will work is obtained easier, faster.

The compactness, low power consumption and low voltage levels of the TR-10 make it the ideal nucleus for on-line computers for process control applications. More time is available for creative engineering. New ideas that were too costly to try before are now practicable.

You can design virtually to perfection and have a permanent, visual record of performance before building pilot models or prototypes. As a result, "cut and try" expense is reduced.

The same quality workmanship and design that has made Electronic Associates the world's leading producer of precision general purpose analog computers will be found in this new unit. Accuracy to ±0.1 per cent. Modular construction allows you to select varying quantities of the following computing functions: summation, integration, multiplication or division, function generation, parameter adjustment, logical comparison.

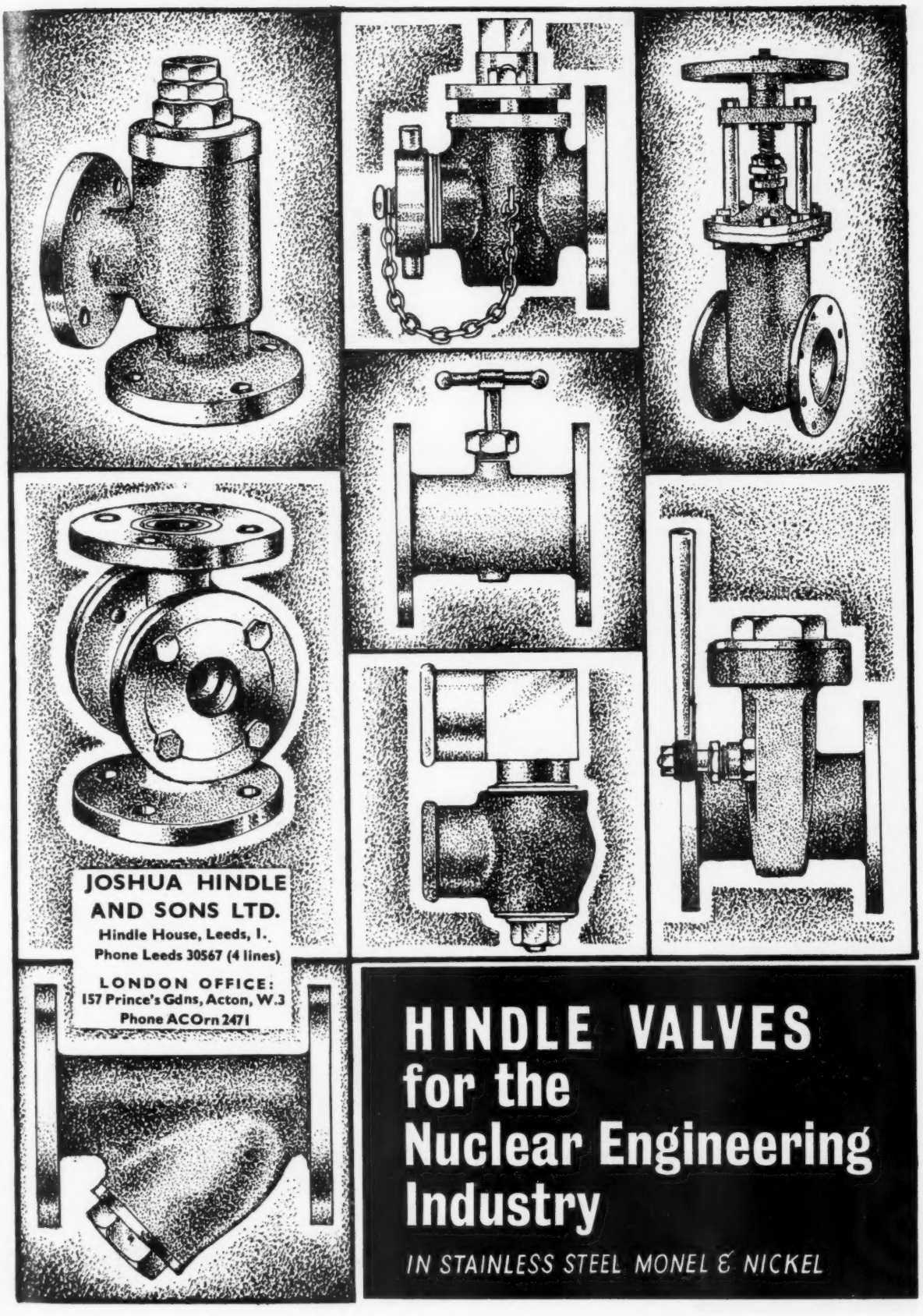
FOR COMPLETE ENGINEERING DATA ON TR-10 OR THE LARGER PACE 231R COMPUTERS WRITE OR PHONE

EAI

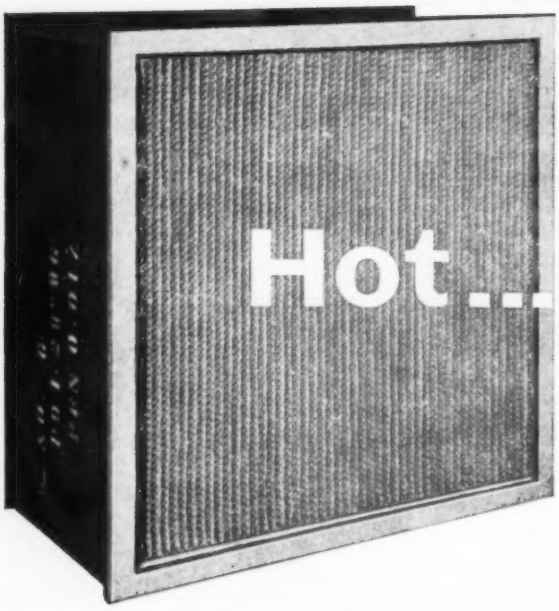
ELECTRONIC ASSOCIATES INC. EUROPEAN DIVISION 43 rue de la Science, Brussels 4 - Belgium
Tel Brussels 11.43.69 - Telex 02-106 Pacebelg Bru

ELECTRONIC ASSOCIATES LTD. WORKS AND HEAD OFFICE Victoria Road - Burgess Hill - Sussex - England
Tel Burgess Hill 26.36 - Telex 8750 Paco Burgesshl

PRODUCERS OF PACE ANALOG COMPUTERS
TRADE MARK

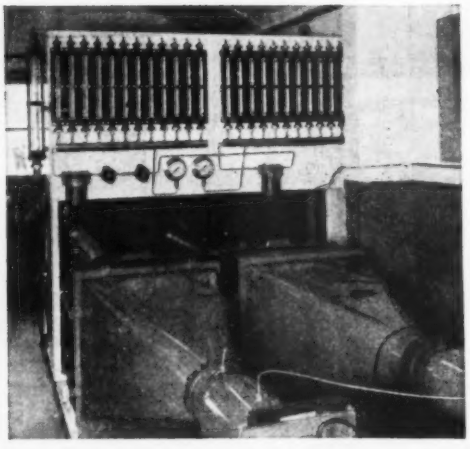


Circle **No 35** on reply card for further details



but not bothered

Vokes high temperature 'Absolute' filters



Vokes High Temperature 'Absolute' filters are tested in accordance with BSS. 2831 on the methylene blue test rig illustrated above. Every filter is subjected to a stream of air containing particles of methylene blue 'dust' ranging in size from 0·1 to 0·5 microns, and rejected if its efficiency is less than 99·99%. Vokes is the only British company which *guarantees* minimum performance figures in this way and Vokes filters are therefore widely used in all applications which require *scientific* filtration.

These filters have been designed for applications involving very high temperatures or risk of fire—for example in nuclear power stations where a breakdown in the filtration system due to an outbreak of fire might release dangerous toxic particles into the atmosphere.

They will withstand temperatures up to 1,000°F and are available in standard sizes as manufactured for the Atomic Energy Authorities. Similar in appearance to the 55 'Absolute' panels from which they were developed, Vokes high temperature filters have an all-glass paper filter medium with aluminium separators, refractory sealers and metal frames. The efficiency of this type of 'Absolute' is even greater than the very successful '55' panel, giving a penetration of only 0·01% against a methylene blue dust cloud.

A booklet on Vokes special purpose air filters is available on request.

The APPROVED filter for fire resistant applications

(Pat. applied for)

VOKES

VOKES LIMITED · GUILDFORD · SURREY

Telephone: Guildford 62861 (6 lines) *Telegrams:* Vokesacess, Guildford, Telex. *Telex:* 8-535 Vokesacess, Gfd.

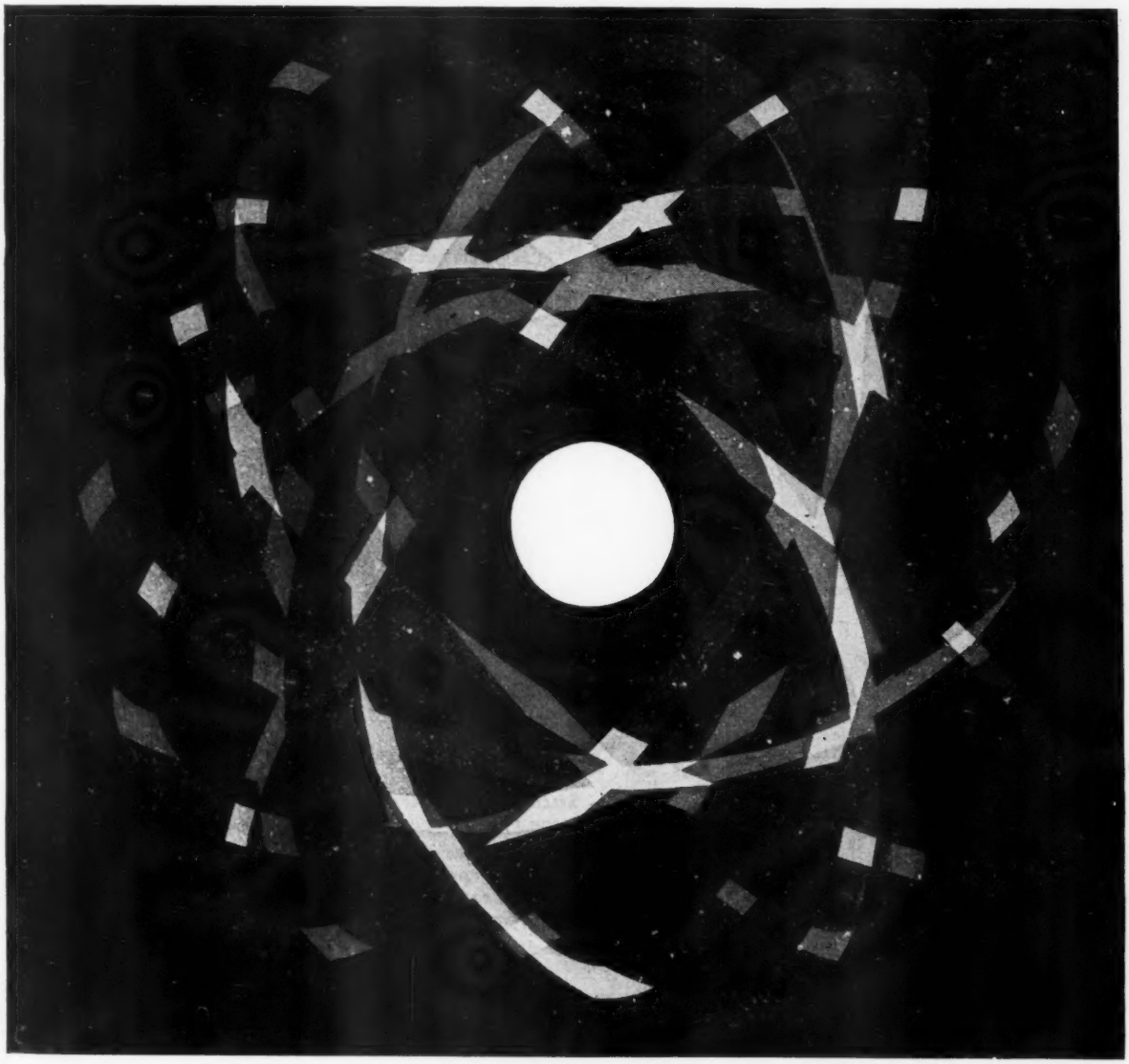
Represented throughout the World.

V.534

ATOMIC FAIREY

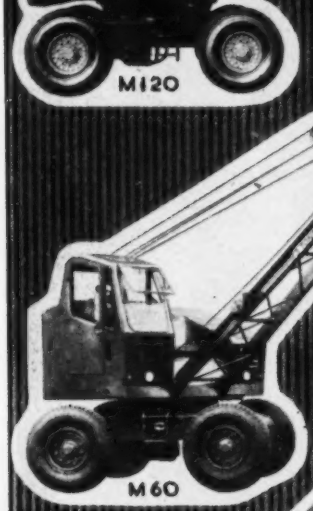
What are Fairey's doing in Atomics? What aren't they? Aluminium and steel fabrications, charge machines, control mechanisms, graphite machining and laying, irradiated fuel disposal equipment, gas filtration . . .
At Britain's latest nuclear power station at Trawsfynydd, as in so many other projects, Fairey are there . . . at the heart of things. They are at work on a major programme of research, development, design and manufacture for nuclear power stations and experimental establishments throughout the country. Fairey have been thinking and living nuclear engineering for years—they know what they're about.
Fairey's nuclear work includes: U.K.A.E.A. experimental reactor equipment, power reactor equipment, fuel element cans, controlled thermonuclear research equipment, aluminium and steel fabrications nuclear fuel processing equipment, plastics and plastics fabrications, electronics and special instrumentation, machine tools and remote handling equipment, hydraulic equipment and gas filters.

Fairey Engineering Limited Heston · Middlesex Stockport · Cheshire *(A member of The Fairey Group of Companies)*



Circle **No 37** on reply card for further details

MORRIS



DIESEL-ELECTRIC

MOBILE CRANES

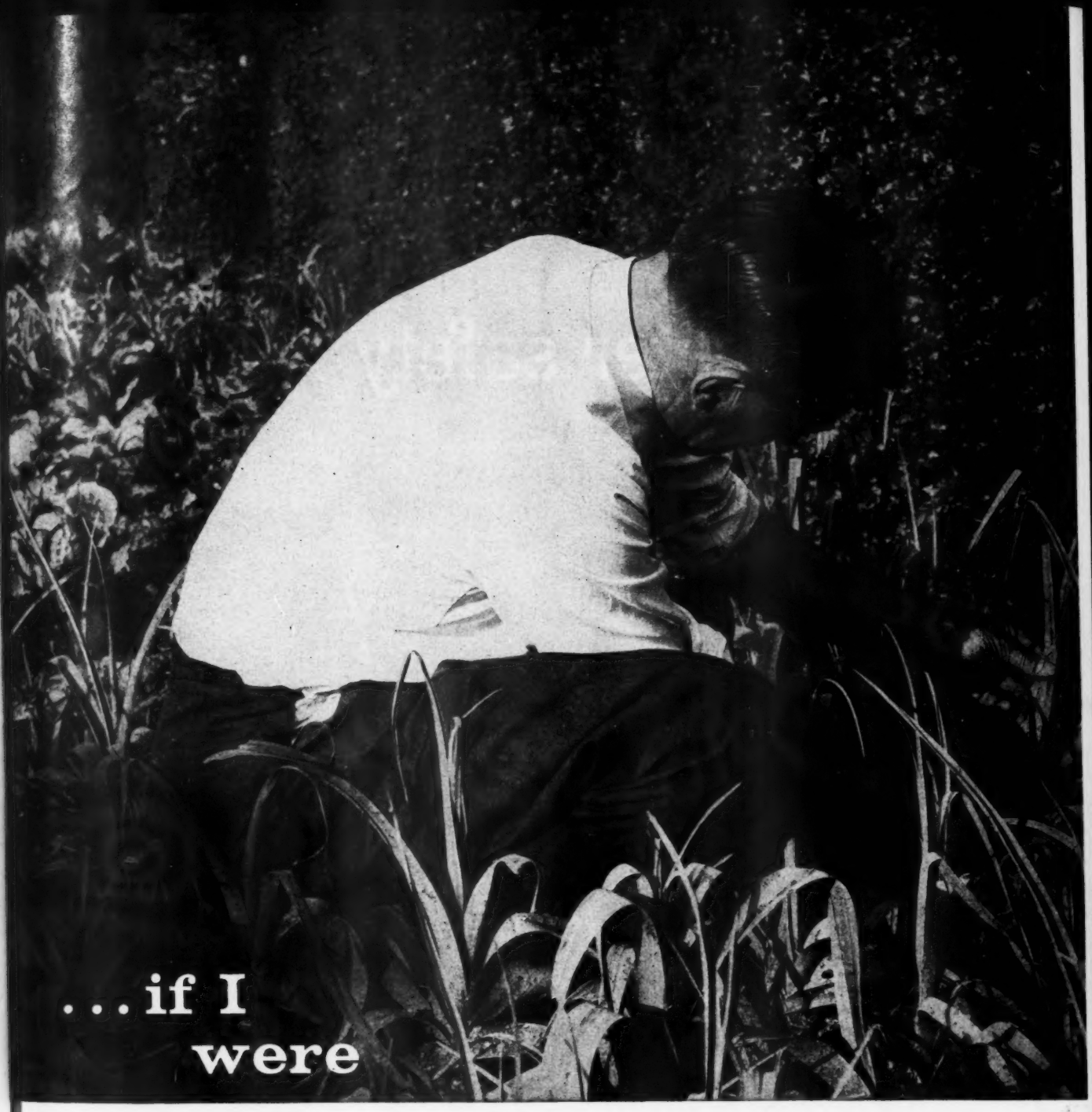
In addition to the **MORRIS** Mobile Crane shown in the appropriate modernity of Dounreay Nuclear Power Station, we illustrate the 6-ton M.120, 3-ton M.60 and 6-ton M.100 cranes.

The capacities, types and lengths of jib available, provide a comprehensive range of robust, reliable cranes, designed to fulfil efficiently most industrial mobile crane requirements.

For detailed particulars write for brochure S46/35.

HERBERT MORRIS LTD P.O. BOX 7 · LOUGHBOROUGH · ENGLAND

TELEPHONE: LOUGHBOROUGH 3123



managing director

...They always say that the leaves grow greener in the other fellow's garden—but I doubt it.

"Seems to me that being a Managing Director would have its drawbacks. Having to entertain customers when I fancied a yarn with the boys and only seeing a leek when it was dished up in a tureen would drive me fair barmy inside a month.

"Mind you—don't get me wrong. If somebody offered me the job I'd have a shot at it, but deep down I feel that the boss's chair calls for a little more than most of us can give. In the 40 years I've worked for the AW Group I've learned to handle men and make a quick decision. I can talk about steel until the cows come home and I know a few tricks that the professors don't teach . . . but as for being a Managing Director . . . I reckon I'll stick to my own garden after all."

STEEL CASTINGS—with the emphasis on quality

JMI

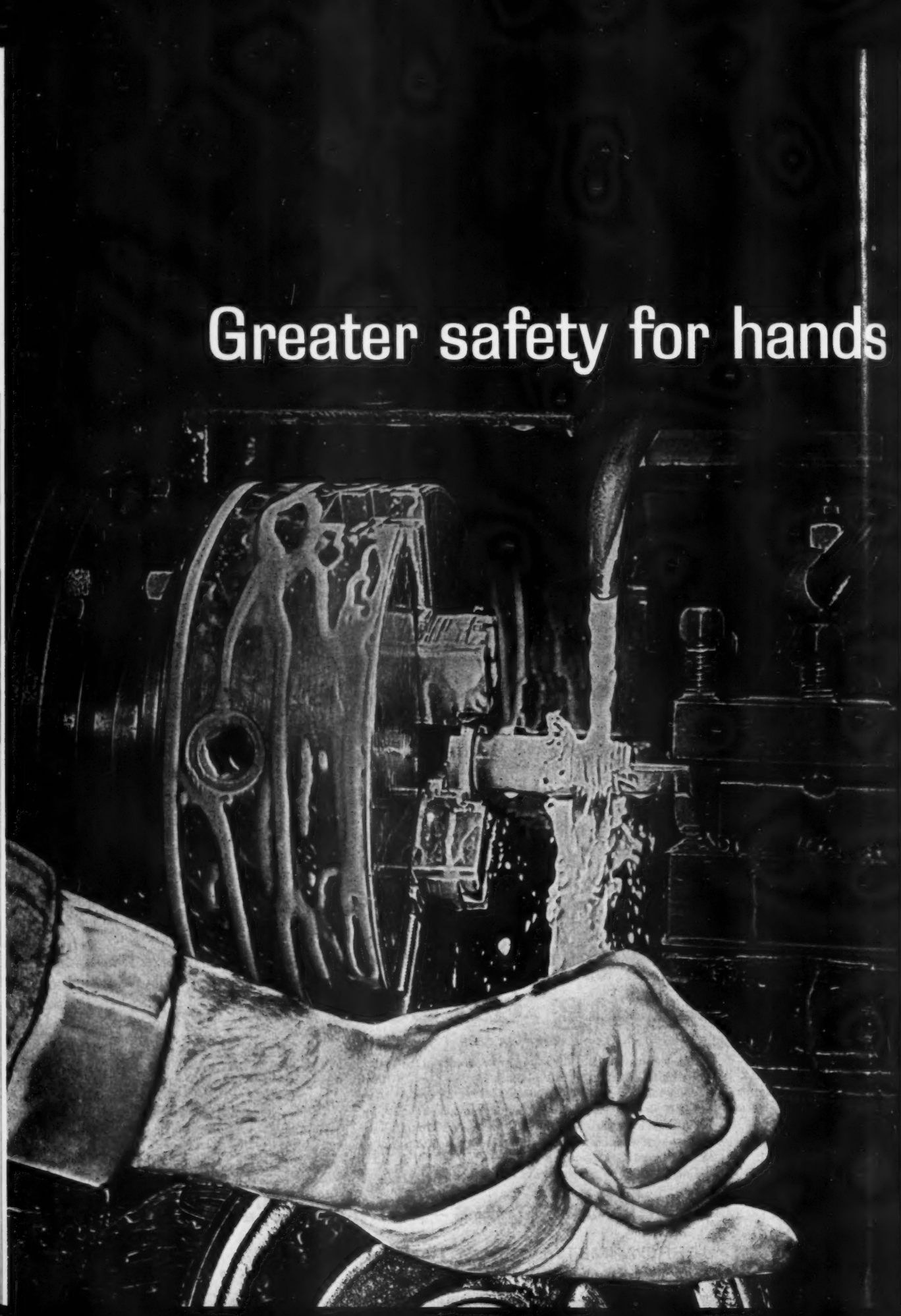
JARROW METAL INDUSTRIES LIMITED

Western Road · Jarrow · Co. Durham · Telephone: 89-7111

Circle **No 39** on reply card for further details

Subsidiary Company of Armstrong Whitworth (Metal Industries) Ltd · Close Works · Gateshead Upon Tyne 8

Greater safety for hands



With new Shell Dromus Oils

Most modern soluble cutting oils contain phenolic compounds used as coupling agents between the oil and the emulsifier, for better blending and easier mixing. These phenolic compounds can cause skin irritation, especially where modern high-speed machines are used and the emulsion can concentrate, through the evaporation of water, above the safety level.

Shell research chemists have been working on this problem, which has been causing some concern to Management. After considerable research, Shell Dromus Oils have been reformulated and these new cutting oils now produce bland emulsions, which considerably reduce the risk of skin trouble to operators.

The real difficulty was to find a new coupling agent to replace the phenolic compounds, and Shell finally used what their chemists know as a higher fatty alcohol complex. This solved one problem, but presented another. The new coupling agent was volatile at the high temperatures normally used in blending processes. Further research found a solution to this problem by designing and installing new plant.

The new Dromus Oils are every bit as efficient as before and cost no more. They put Management in the welcome position of being able to minimise working hazards at no extra cost. And machine men need no longer be so worried about skin troubles.

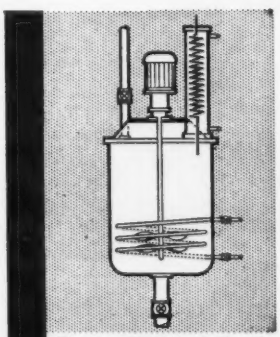
The moral of the story is that Shell research is supremely applicational. The centre at Thornton is always ready to work with even the most specialised sectors of industry to produce the right oil for the job. If you and your organization have any major lubricating problems, it pays to get in touch with your local supplier of Shell Industrial Lubricants.

The Research Story

Shell chemists in the U.K., in Holland and in the U.S.A., prepared and examined hundreds of experimental soluble oils, and established that certain combinations of fatty alcohols could be used in place of phenolic compounds with no loss of efficiency. They set to work to discover the best combination and developed a higher fatty alcohol complex which fitted exactly. Then they realised that to blend this new coupling agent into soluble oils would require special plant and new blending techniques.

Exhaustive testing of blend stability, emulsion stability, anti-corrosion and machining properties led to selection of the most promising blends. A pilot plant was set up to produce batches of these for use in field trials.

This field testing and final development proceeded for two years whilst production plants were erected at points so chosen as to give the most economical and rapid delivery throughout the United Kingdom.



This is the blending kettle. The reflux condenser beside the stirrer motor prevents the loss of constituents volatile at the blending temperature.

NEW SHELL DROMUS SOLUBLE CUTTING OILS

another proof of Shell leadership in lubrication

Circle **No 41** on reply card for further details

ARGON

BUTADIENE

BUTANE

For efficient storage and transportation of liquid gases

ETHYLENE

FLUORINE

METHANE

NITROGEN

OXYGEN

PROPANE etc.

get in touch with - - -

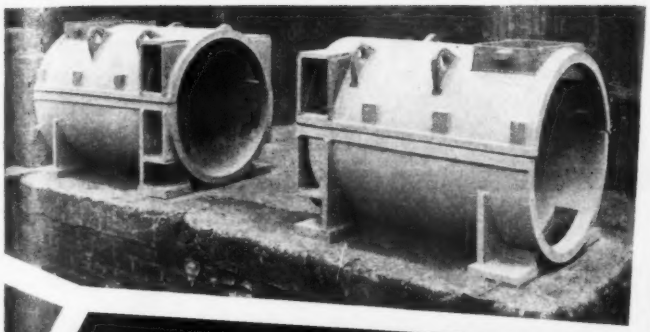
Butterfields of **SHIPLEY**

FABRICATORS IN STAINLESS STEEL · MILD STEEL ALUMINIUM · ALUMINIUM BRONZE ALLOY 'MONEL' AND NICKEL

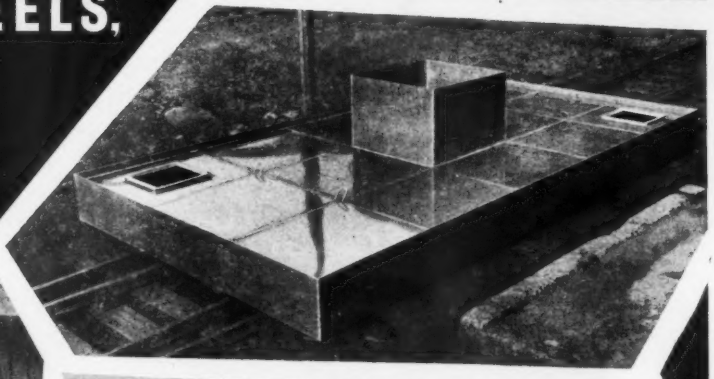
W P. BUTTERFIELD LTD.
P.O. Box 38 · SHIPLEY · YORKS.
Telephone: 52244 (8 lines)

BRANCHES:
London Tel: HOLborn 2455 (4 lines)
Birmingham Tel: EAS 0871 & 2241
Bristol Tel: 27905
Liverpool Tel: CENtral 0829
Glasgow Tel: CENtral 7696
Belfast N.I. Tel: 57419 & 51957
Dublin Tel: 73475 & 79745

Circle **No 42** on reply card for further details

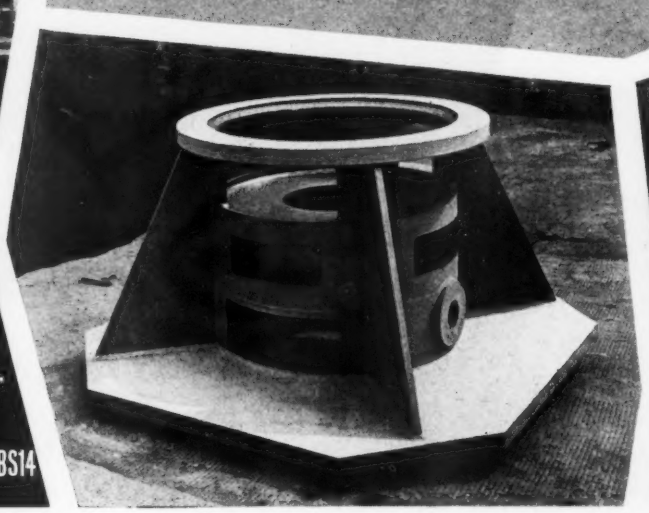


For General Fabrication in MILD STEELS, STAINLESS STEELS, and ALUMINIUM ALLOYS

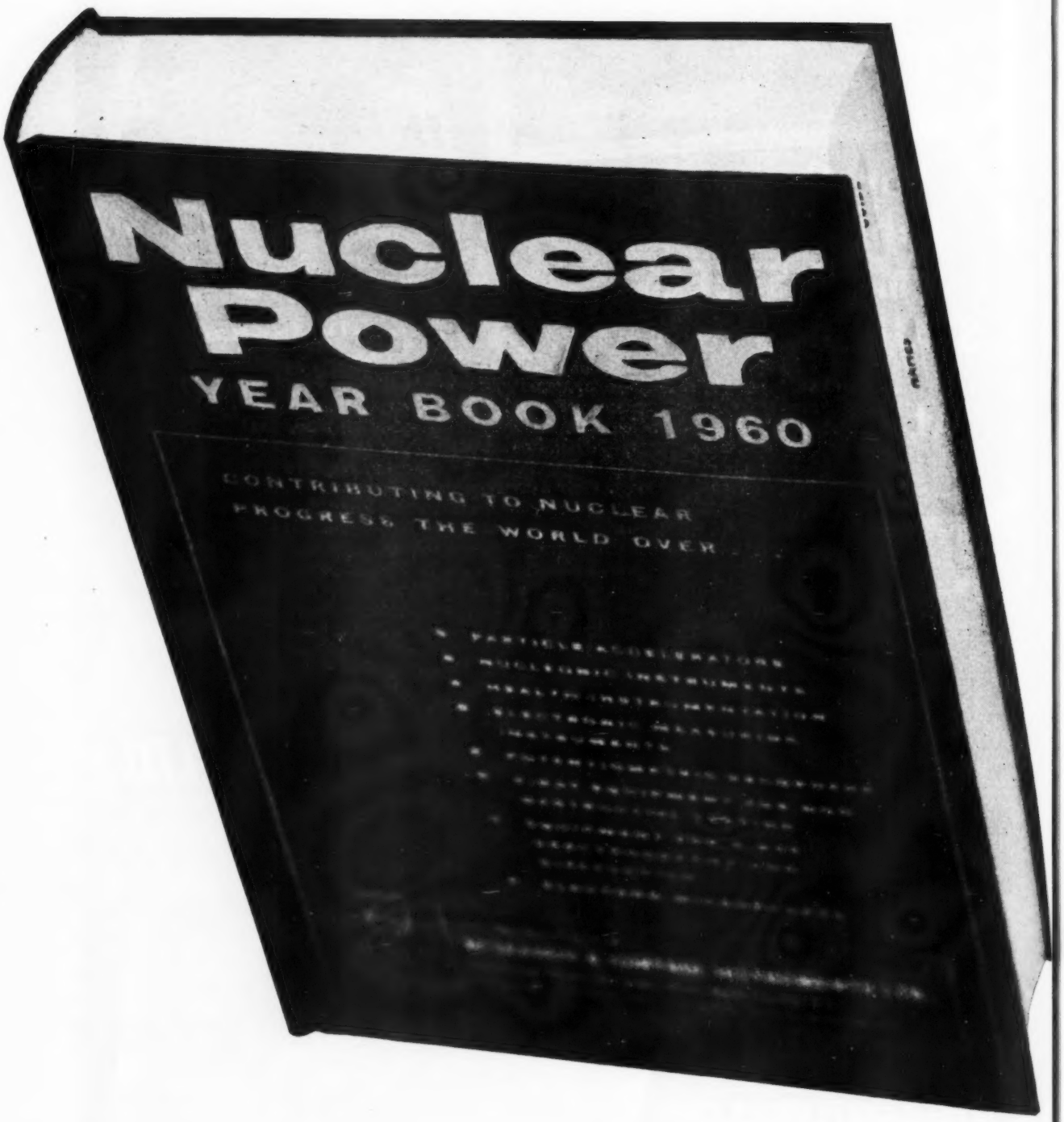


ROBERTSON & FERGUSON LTD.

29 MURIESTON CRESCENT, EDINBURGH, 11. Tel: DON 5222



WE ALSO SPECIALISE IN DISHED AND FLANGED ENDS
MAX. DIA. 24" MAX. THICKNESS ½"
Made to suit Customer's inspection requirements from BS14


Nuclear
Power
YEAR BOOK 1960
CONTRIBUTING TO NUCLEAR
PROGRESS THE WORLD OVER

THE 1960 NUCLEAR POWER YEAR BOOK & BUYERS' GUIDE

NOW IN ITS 3rd EDITION

the Nuclear Power Year Book and Buyers' Guide is the only comprehensive publication of its kind in the world

CONTENTS

1 1960 Review
An uptodate critical review of the British nuclear power scene, details of the British nuclear contracting groups and the electricity generating authorities, data on British reactors, map of nuclear energy establishments and power stations.

2 World Authorities
The history, organization and plans of all national atomic energy authorities and international bodies. Addresses of establishments and names of leading officials.

3 Technical Data
Articles and tables on reactor physics, instrumentation and special metallurgy.

4 Isotope Section
A 60-page table giving the principal properties of all known nuclides including indication of sources of supply. Precautions to be taken in the use of radioactive substances.

5 Company Addresses
Titles, addresses, directors, home and overseas branches of nearly 2000 British firms supplying the nuclear energy industry.

6 Buyers' Guide
Firm's products classified under 750 different headings.

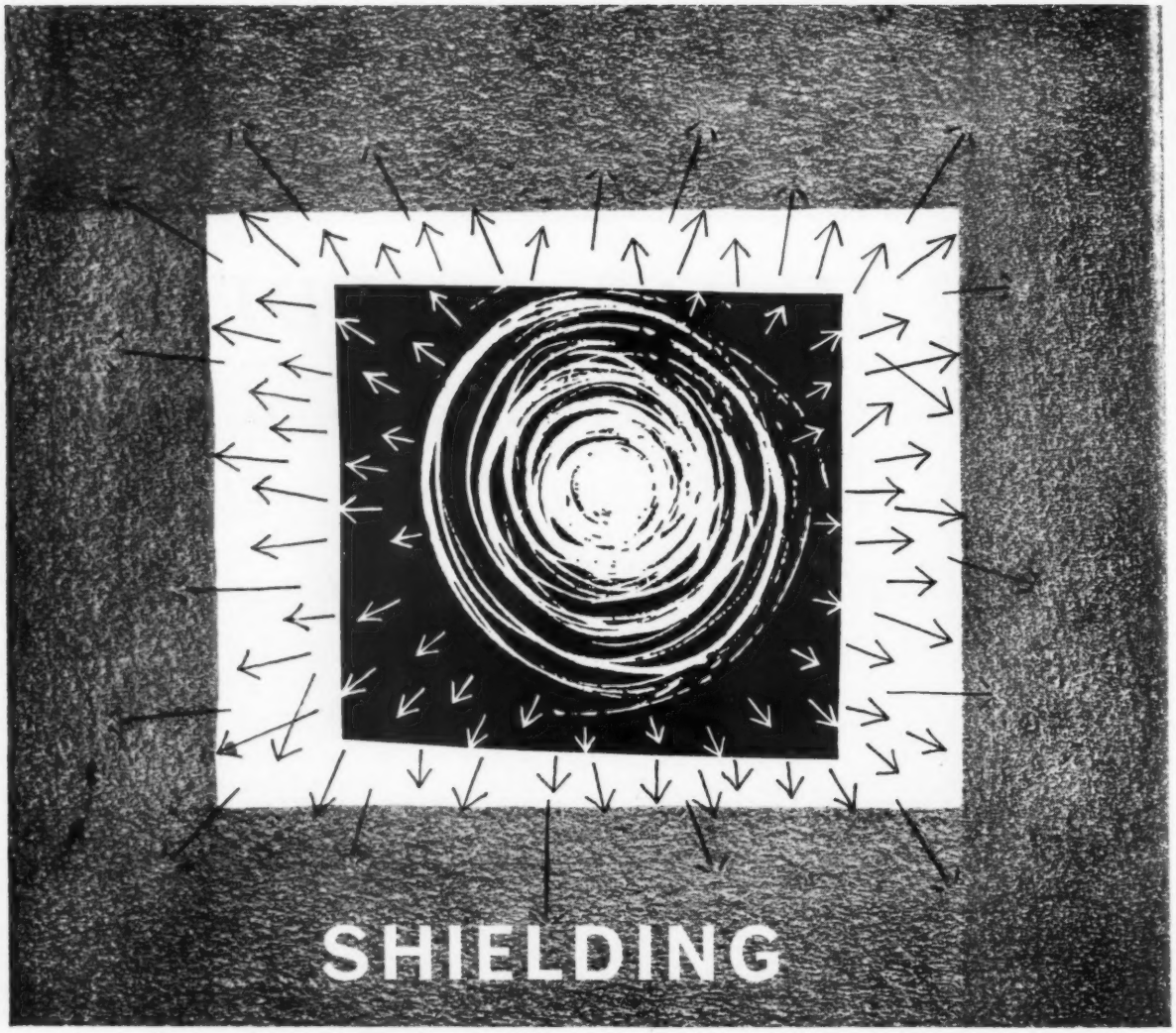
7 Trade Names
Products identified under registered titles.

8 Who's Who
Biographical details of over 600 leading men in British nuclear energy.

Revised from cover to cover the 3rd edition of NUCLEAR POWER YEAR BOOK and BUYERS' GUIDE is essential for management, designers, operators and research workers in the field of atomic energy.

Order your copy now—price £2.12.6 (post free)

ROWSE MUIR PUBLICATIONS LIMITED,
THE ROWSE MUIR BUILDING, 77-79 CHARLOTTE STREET, LONDON, W.1, ENGLAND

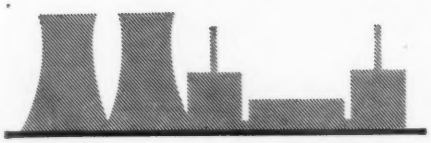


FROM RADIATION

We have a long history in working with lead as well as substantial engineering and metallurgical resources, and will co-operate, from drawing board to installation, on any lead or lead/polythene shielding jobs which are required in these days of nuclear development. We have in general use at our Works comprehensive testing facilities, including gamma-ray radiography, scintillation counting and ultrasonic testing equipment, and will welcome the opportunity of quoting you for any radiation shielding work which you may require.

ASSOCIATED LEAD MANUFACTURERS LIMITED

CLEMENTS HOUSE, 14 GRESHAM ST., LONDON, E.C.2 · CRESCENT HOUSE, NEWCASTLE · LEAD WORKS LANE, CHESTER



the latest techniques in nuclear engineering...

Drilled and machined flanges for Atomic Energy Power Stations

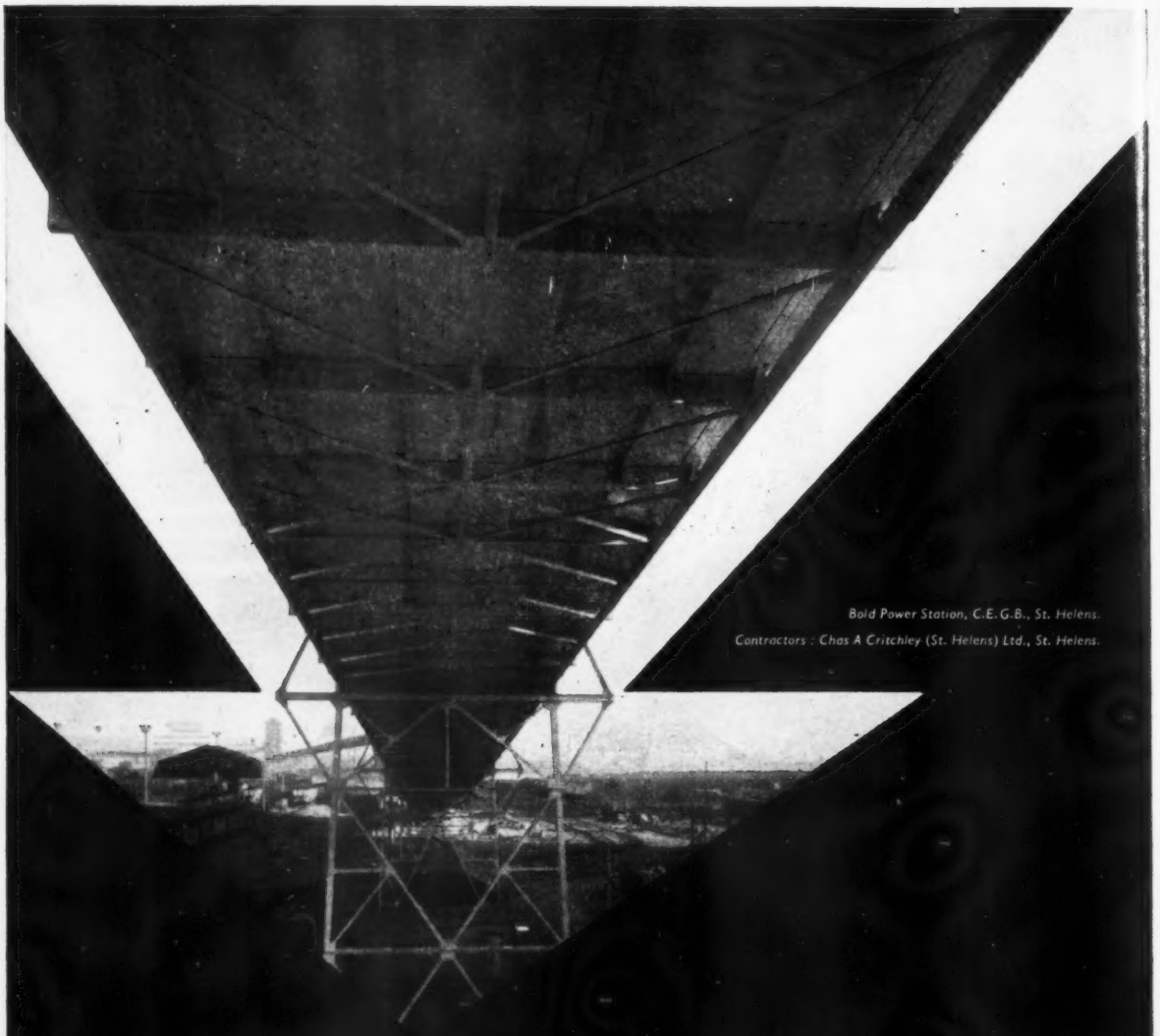
...demand special alloy steel forgings

by **FIRTH BROWN**

ALLOY STEELMAKERS · FORGEMASTERS · STEEL FOUNDERS · HEAVY ENGINEERS

THOS FIRTH & JOHN BROWN LIMITED · SHEFFIELD · ENGLAND

Circle **No 47** on reply card for further details



Bold Power Station, C.E.G.B., St. Helens.
Contractors : Chas A Critchley (St. Helens) Ltd., St. Helens.

Prevent CORROSION

Zinc Chromate Primer and Epilux 1 . . . . two outstanding anti-corrosive coatings widely used throughout industry, protect steelwork at Bold Power Station

ZINC CHROMATE PRIMER: A water-resisting medium, ensures maximum defence against corrosion on non-ferrous metals. Cheaper than red lead, it spreads further and more easily, dries faster and harder; good storage life, easy to mix. In yellow, green and red.

EPILUX 1: This air/drying enamel is based upon Epoxy resins. It possesses remarkable flexibility and abrasion resistance. In addition Epilux 1 has shown exceptional ability to withstand the attack of alkalis and mild acids . . . good resistance to water, excellent adhesion. Superior to traditional gloss paints in heavily chemical laden atmospheres

ZINC CHROMATE PRIMER ✣ EPILUX 1

BRITISH PAINTS LIMITED *Industrial Maintenance Division*

PORTLAND ROAD, NEWCASTLE UPON TYNE, 2. NORTHUMBERLAND HOUSE, 303-306, HIGH HOLBORN, LONDON, W.C.1. 31, WAPPING, LIVERPOOL, 1.
Belfast, Birmingham, Bristol, Cardiff, Glasgow, Leeds, Manchester, Norwich, Plymouth, Sheffield, Southampton, Swansea, and all principal towns.

A Vital contribution to Atomic Power . . .

"WANDLESIDE"

ARMOURED CABLE

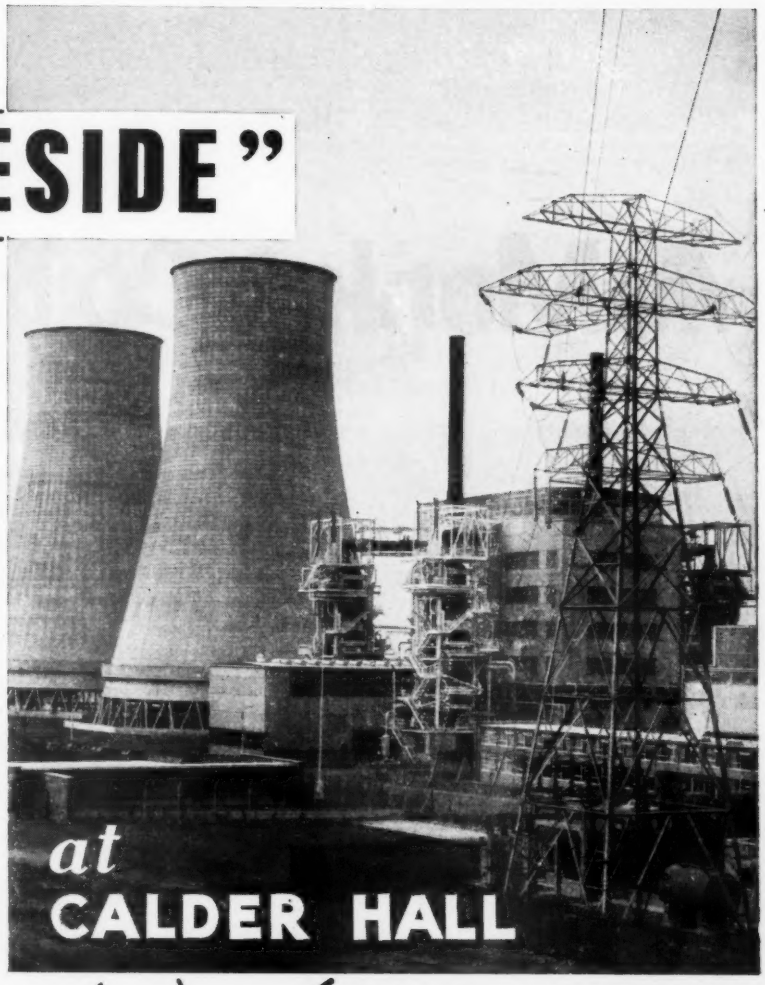


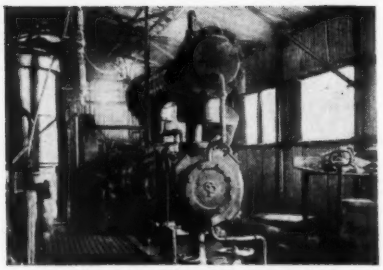
Photo by courtesy U.K. Atomic Energy Authority

With the advancement of Atomic Power, cables must play an important part in the efficiency and reliability in the production of Nuclear Energy. Only the best is good enough and Wandleside Cables are eminently suitable.

WANDLESIDE CABLES *for Nuclear Energy*

WANDLESIDE CABLE WORKS LTD. 106 GARRATT LANE WANDSWORTH LONDON, S.W.18
One of FALKS Group *Telephone: VANdyke 7544 (5 lines)* *Telegrams: Wandleside, London*

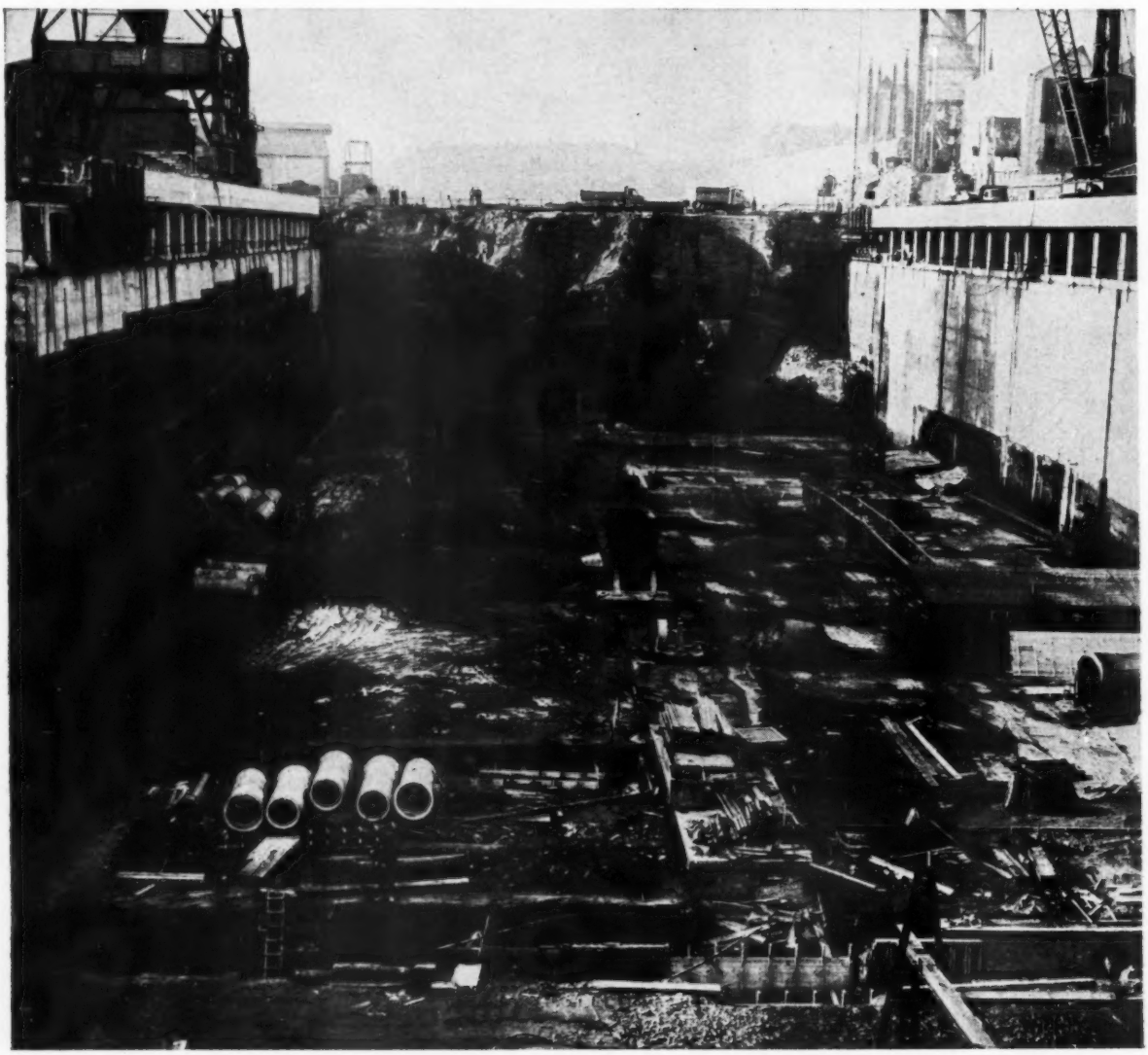
ON THE CAMMELL LAIRD NEW DRY DOCK



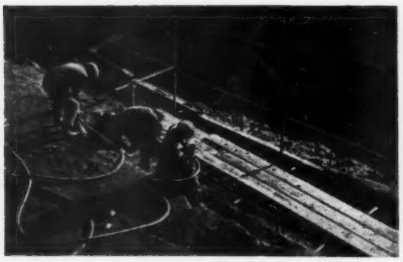
One of two Consolidated Pneumatic, horizontal, slow-speed, double-acting type TCB Compressors, supplying air for operating pneumatic tools.

A. Monk & Co make full

A general view of part of the excavation for Cammell Laird's new No. 5 Dry Dock, on which CP-32 rock drills were employed.



A Consolidated Pneumatic No. 77 Sludge Pump in service to deal with seepage.



(and below) Squaring up the excavations with Consolidated Pneumatic No. 117 Breakers'

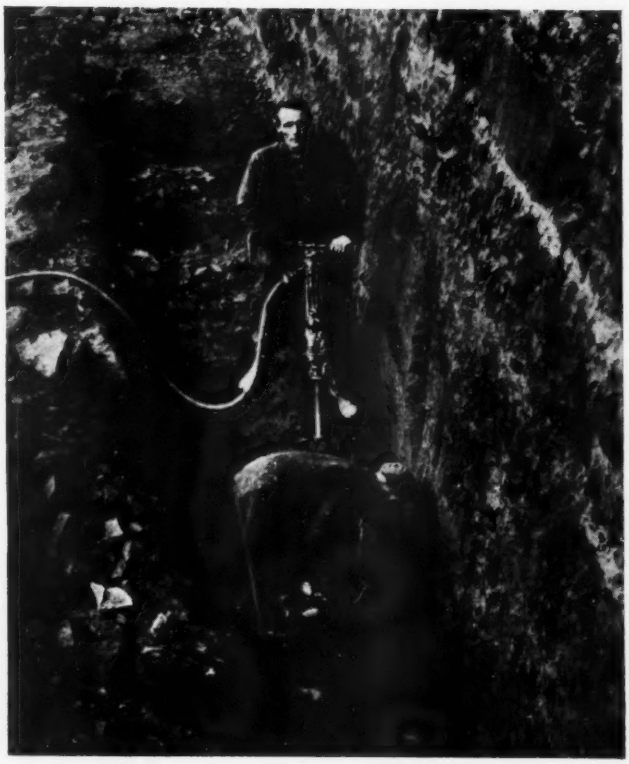
A Consolidated Pneumatic type 125-RO-2 rotary 'Power Vane" compressor in service on the new dry dock site.

use of CP equipment

Construction work, now well under way for Cammell Laird's new Birkenhead Dry Dock, is one of the many large projects on which leading Civil Engineering Contractors, A. Monk & Company Limited are currently engaged.

The new Dock involved the use of rock drills for the excavation of some 400,000 cu. yards of hard sandstone, and other operations called for compressed air equipment, such as pneumatic pumps to deal with seepage, breakers and picks for trenchwork and trimming, and grinders for surfacing.

The progress of the contractors, as shown in these pictures, is a tribute to the performance of CP compressors and plant put into service by A. Monk & Company Limited on these operations.

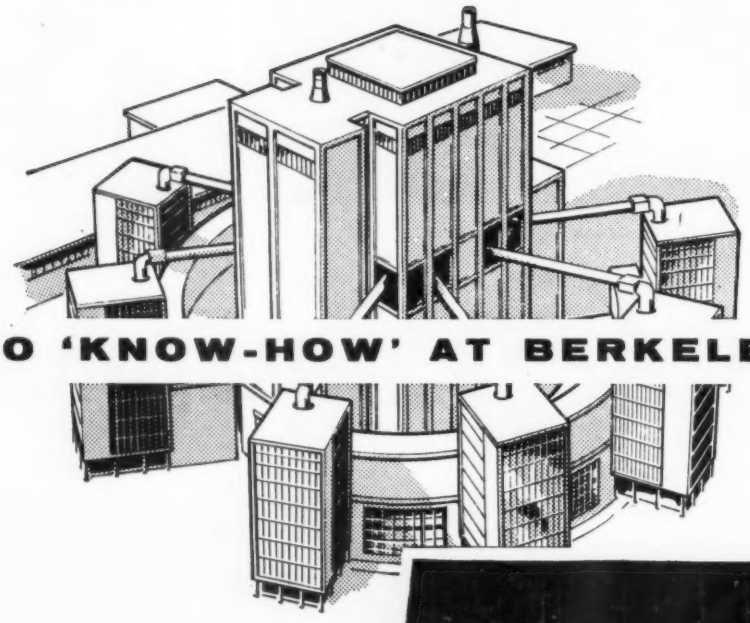


Photos published by the courtesy of Messrs. Cammell Laird (Shipbuilders & Engineers) Ltd. Consulting Engineers: Rendel, Palmer & Tritton

Consolidated Pneumatic

CONSOLIDATED PNEUMATIC TOOL CO. LTD · DAWES ROAD · LONDON · S.W.6

CP/214



EFCO 'KNOW-HOW' AT BERKELEY.....

Reactor pressure vessel stress relieving installation planned, erected and supervised by EFCO

Efco heating equipment inside the world's largest reactor pressure vessel ever to be stress relieved.

ELECTRIC RESISTANCE FURNACE CO., LTD.

NETHERBY, QUEEN'S ROAD, WEYBRIDGE, SURREY Weybridge 3891

NRP/R3054

THIS

is all in the day's work

Just a 10,000 gallon capacity glycol storage tank in light alloy.* But it is *unusually* well made, because Marston's possess a wealth of experience in non-ferrous metal fabrication. And it does demonstrate once again that when people want something better than the usual, they come to us. If you're contemplating engineering, chemical, petroleum or nuclear power plant that calls for components to unusual specifications, consult us at the design stage: our experts can contribute much to the smooth, speedy and economical execution of your plans.

Process plant · Bursting discs
Pressure vessels · Heat-exchangers
Pipework · Special-purpose machines
in aluminium, titanium and other non-ferrous metals.

* Made for I.C.I. Dyestuffs Division.

ICI

MARSTON EXCELSIOR LIMITED

A subsidiary of Imperial Chemical Industries Limited

Fordhouses Wolverhampton

MAR.279

WHEN YOU ARE

"thinking big"

THINK OF

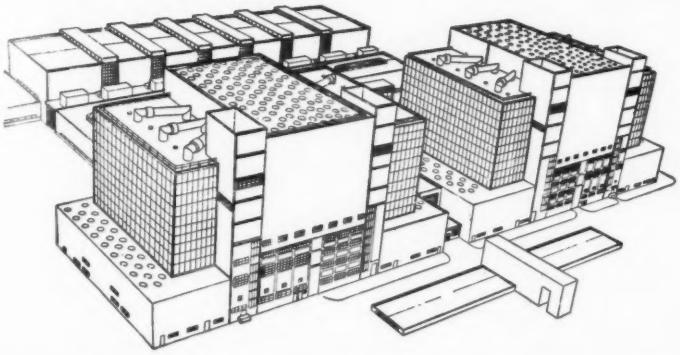
HARVEY

G. A. HARVEY & CO.
(LONDON) LTD.
WOOLWICH ROAD, LONDON, S.E.7
GREenwich 3232 (22 lines)

Gas from Oil: For the South Eastern Gas Board's high pressure Oil Gasification installation, now being built by Woodall-Duckham Construction Co. Ltd., Harveys have made and delivered to the Isle of Grain two Absorber columns. Each column is 120 ft. long by 9 ft. 4 ins. overall diameter, and weighs approximately 100 tons. The columns are Class 1 welded throughout, for operation at 300 p.s.i., and are for the high pressure CO_2 removal plant.

Harvey Facilities and Products: CLASS 1 WELDED PRESSURE VESSELS TO LLOYD'S AND A.S.M.E. CODES · HEAT TREATMENT AND RADIOGRAPHY · DIE-PRESSED AND 'ROTAR-PREST' HEADS UP TO 15 FT. DIA.—LARGER SIZES TO SPECIFICATION · FABRICATIONS UP TO 120 TONS IN ONE PIECE · STEEL PLATE AND SHEET METALWORK · HEAVY MACHINING AND FITTING · PERFORATED METALS · WOVEN WIRE HF/13

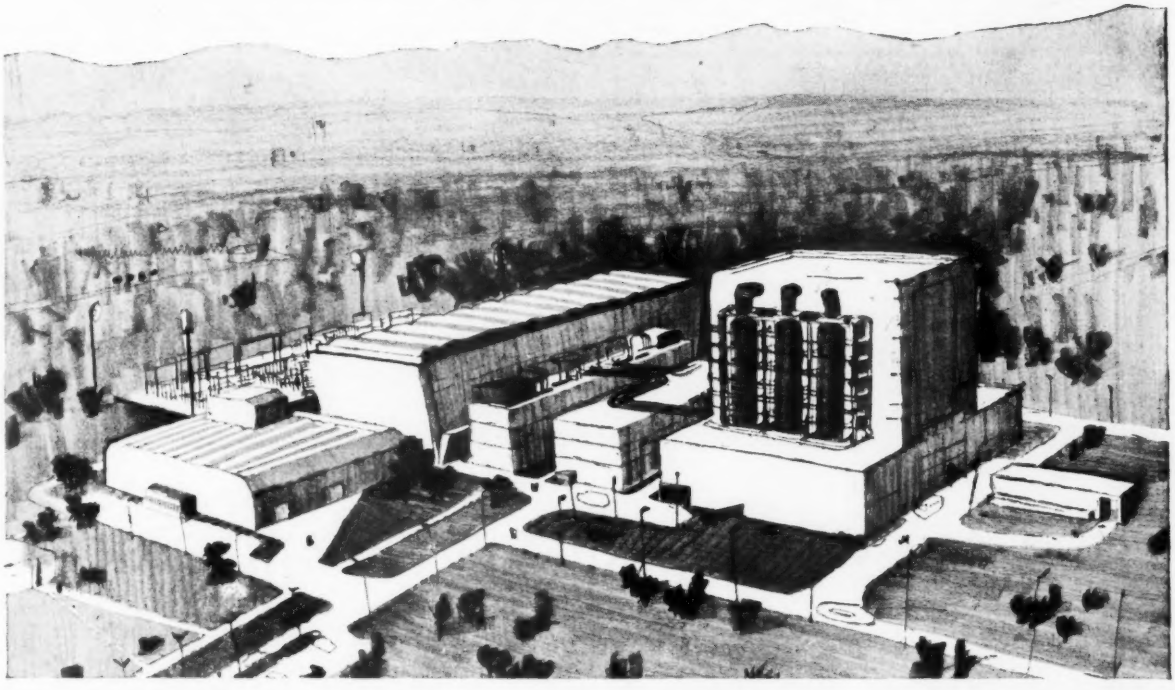
MANCUNA-DUSTEX THE MOST EFFICIENT MINIATURE CYCLONE DUST COLLECTOR IN THE WORLD



First – Bradwell Essex

NOW AT LATINA, ITALY

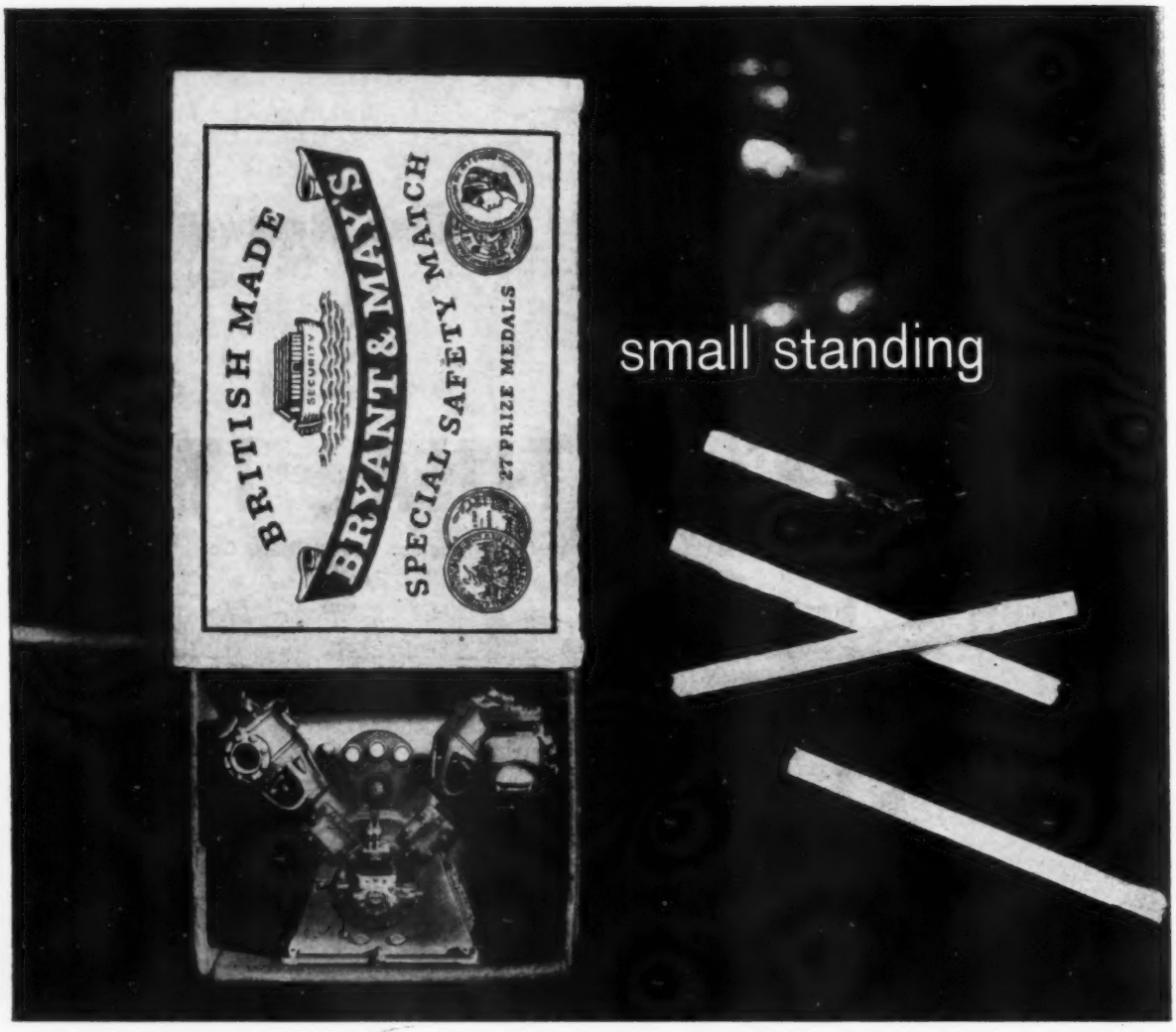
In conjunction with Agip Nucleare and The Nuclear Power Plant Co.



MANCUNA HIGH EFFICIENCY MINIATURE CYCLONES FOR CO2 BYPASS & DRIER FILTERS

MANCUNA ENGINEERING LTD., DENTON, MANCHESTER. Tel.: Denton 3965 (5 lines)
Specialists in Gas Cleaning and Dust Technology
London Office: 59 VICTORIA ROAD, SURBITON, SURREY. Tel.: Elmbridge 9793

MANCUNA



the Joy WN112 stationary compressor

Exacts less space — extracts more power. Match it against any other two stage industrial air compressor. You won't find one combining Vee-twin construction, flange-mounted motor and small floor space requirements in such striking degree.

Small-standing, country-quiet, sentry-still JOY industrial compressors are fully described in publication AD/6. Please write for a copy.

7 Harley Street, London W.1

AIR POWER
JOY-SULLIVAN LTD
DIVISION

11 out of top 20

for thermal efficiency insulated by

DARLINGTON

Blyth 'A'	33.88%
Agecroft 'C'	32.63%
Castle Donington	32.52%
Drakelow 'B'	32.14%
Willington 'A'	31.96%
Drakelow 'A'	30.81%
Rogerstone	30.44%
South Denes	30.11%
Stourport 'B' (HP)	30.04%
Littlebrook 'B'	29.76%
Stella North	29.36%

Here's further conclusive evidence that The Darlington Insulation Co. Ltd. is the leading company of its kind in Britain! Of the twenty power stations that top the list for thermal efficiency in 1959 in the Central Electricity Generating Board analysis, eleven – including the first three – were insulated by Darlington. Eleven good reasons for choosing Darlington for all industrial insulation problems!

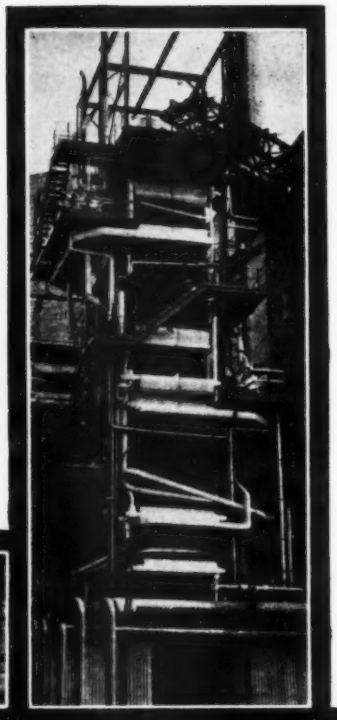
The same comprehensive technical advisory service that achieved these results is available to *you*. Address any thermal insulation problem you may have to

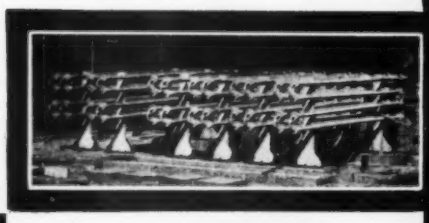
The Darlington Insulation Co. Limited

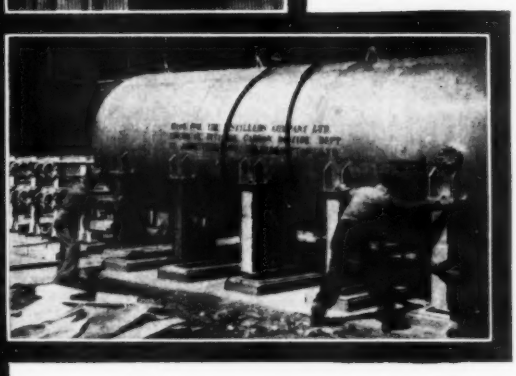
38 Great North Road, Newcastle upon Tyne, 2 *A Member of The Darlington Group of Companies*

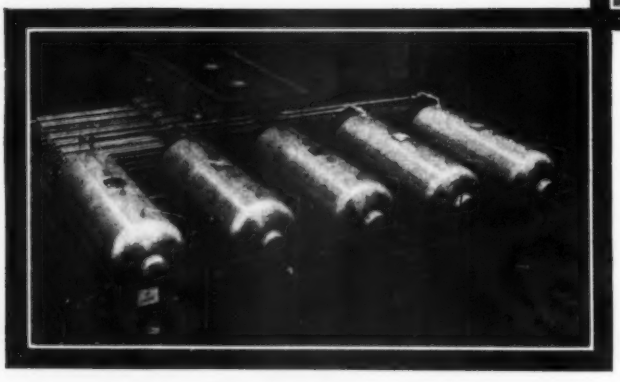
Branches at LONDON: 493 Lea Bridge Road, Leyton, E.10. BIRMINGHAM: 1087 Kingsbury Road, Tyburn, 24.
BOLTON: Roscoe House, Withins Lane, Breightmet. BRISTOL: 125-7 Bishop Street, Portland Square, 2. CARDIFF: 10 Fitzalan Place.
GLASGOW: Vicarfield Place, Govan, S.W.1. LEICESTER: 234 Belgrave Gate. SHEFFIELD: 4-6 South Street.
Acoustic Division: Tyne Works, Scotswood, Newcastle upon Tyne, 5

Calder Hall
Chapelcross
Berkeley
Hunterston
Bradwell
Hinkley Point









DCL know CO_2

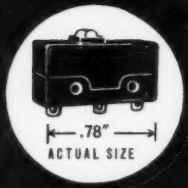
The Distillers Company Limited
Chemical Division—Carbon Dioxide Department
Devonshire House, Piccadilly, London W.1
Telephone: Mayfair 8867

The use of carbon dioxide as a heat transfer medium in nuclear power stations raises many problems. Where storage and vaporization are concerned, The Distillers Company Limited know the answers; and they provided the installations for the purpose at both Calder Hall and Chapelcross.

Other similar, even larger, installations are now being designed or constructed by the Company for the Berkeley, Hunterston and Hinkley Point power stations. The Company has recently also obtained the contract for the supply of carbon dioxide to the Bradwell and Hinkley Point nuclear power stations.

TA/253

off the cuff . . .



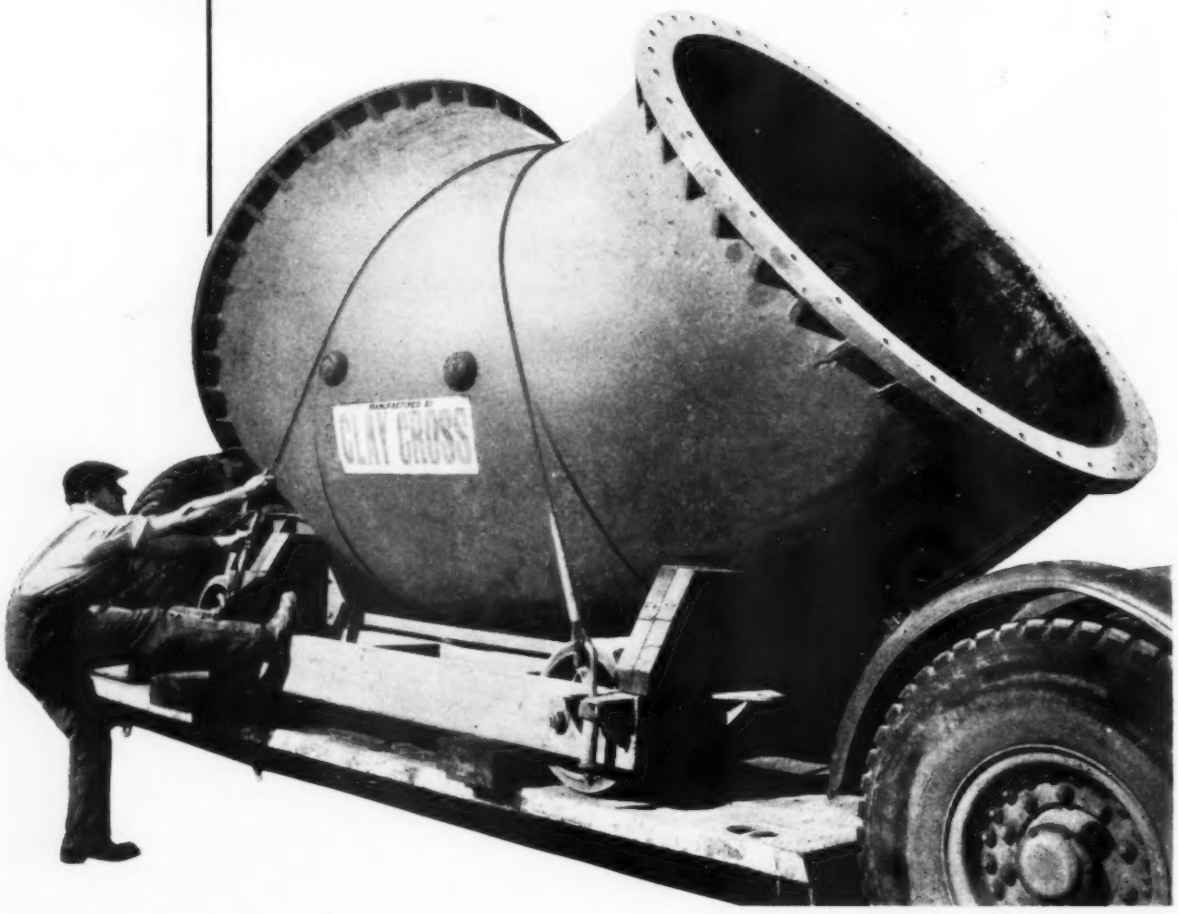
The New BURGESS V-4

* No larger than the average cuff-link
* New mechanism has mechanical life of at least 10 million operations
* Three types of solder terminals available
* Comprehensive range of auxiliary actuators

BURGESS MICRO SWITCHES

BURGESS PRODUCTS COMPANY LTD, MICRO SWITCH DIVISION, DUKES WAY, TEAM VALLEY, GATESHEAD 11
Telephone: Low Fell 75322. Telex: 53-229 London Office: 127 Victoria Street, SW1. Telephone: TATe Gallery 0251 Telex: 25601

CLAY CROSS



CAST IRON PIPES AND BENDS

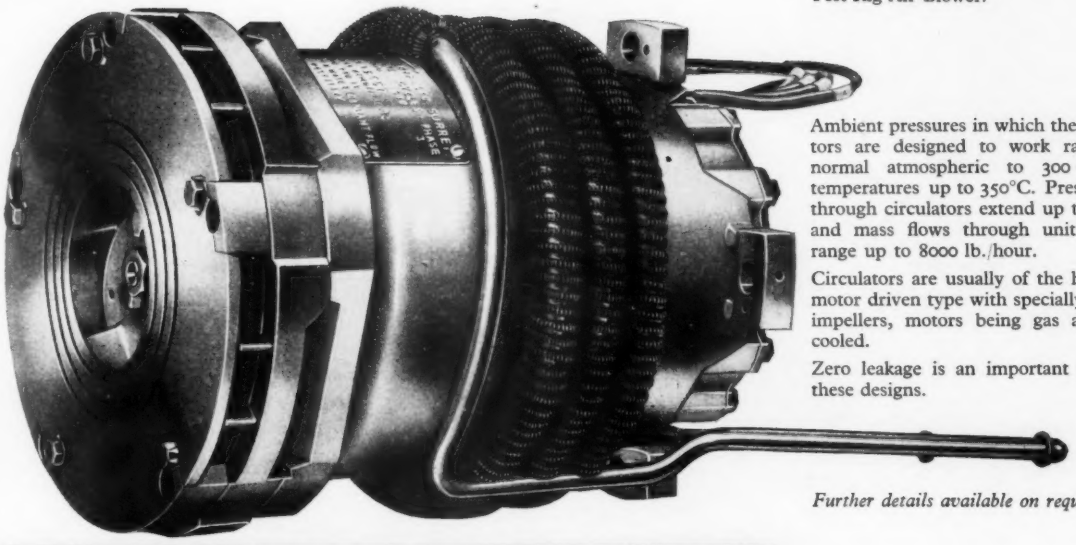
Currently with our daily production of large numbers of spun pipes of all conventional sizes, our foundries are engaged on many special types of pipe castings—straights, bends, tees, etc. This is a recent 84" bend for a dry dock scheme. As well as for standard pipes, we are always pleased to help and advise you on such 'specials' for water distribution, cooling and drainage in power stations and industry.

CLAY CROSS (IRON & FOUNDRIES) LTD., CLAY CROSS, DERBYSHIRE

"PLANNAIR" GAS CIRCULATION BLOWERS FOR NUCLEAR PROJECTS

The AGR 19 Fuel Element Cluster CO_2 circulator, here illustrated, provides for reliable and efficient cooling of nuclear reactors. The blower, with its 11,500 r.p.m. motor (200V 400 c/s supply), is sealed within a long pressure vessel at the opposite end to which the nuclear reaction occurs. CO_2 circulates through the tube at 285 p.s.i. A and 95°C. The blower output is 6300 lb./hour at 7.5 p.s.i. pressure differential. A secondary radial impeller gives a cooling gas circuit via a demineralised water heat exchanger coil which keeps the motor operating at below 75°C.

This is but one of several gas circulating blowers which Plannair have designed for various nuclear projects. These include a Leaky Cartridge Test Rig Air-Blower, a Sodium Loop-Nitrogen Circulator, a Helium Circulator, Air Circulators and a Nitrogen Circulator for R.3 Adam, CO_2 circulator for Fuel Element Cluster Irradiation Test Rig, Burst Fuel Element Test Rig Air-Blower.

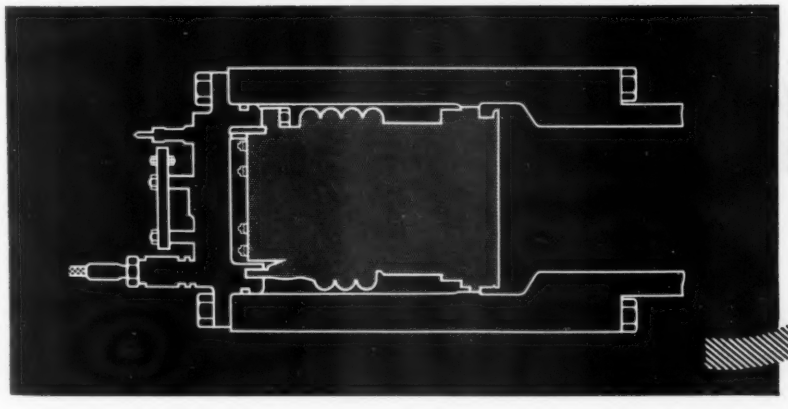


Ambient pressures in which these circulators are designed to work range from normal atmospheric to 300 p.s.i. at temperatures up to 350°C. Pressure rises through circulators extend up to 30 p.s.i. and mass flows through units cover a range up to 8000 lb./hour.

Circulators are usually of the high speed motor driven type with specially designed impellers, motors being gas and liquid cooled.

Zero leakage is an important feature of these designs.

Further details available on request.



PLANNAIR

PLANNAIR LIMITED

Windfield House • Epsom Road
Leatherhead • Surrey
Tel: Leatherhead 4091/3, 2231

PLA39

Circle **No 61** on reply card for further details

Forged Steel Reinforcement Gas Duct Rings

As machined prior to installation 98″ o/d, 68″ i/d, overall width 24″ (by courtesy of Whessoe Ltd.)

As forged and heat treated 101″ o/d, 65″ i/d, overall width 27″ (by courtesy of Whessoe Ltd.)

As machined prior to installation for 3′ 3″ bore inlet duct and duct erection opening for heat exchangers (by courtesy of International Combustion Group)

For Spherical and Cylindrical Vessels as supplied for the above NUCLEAR POWER PLANTS

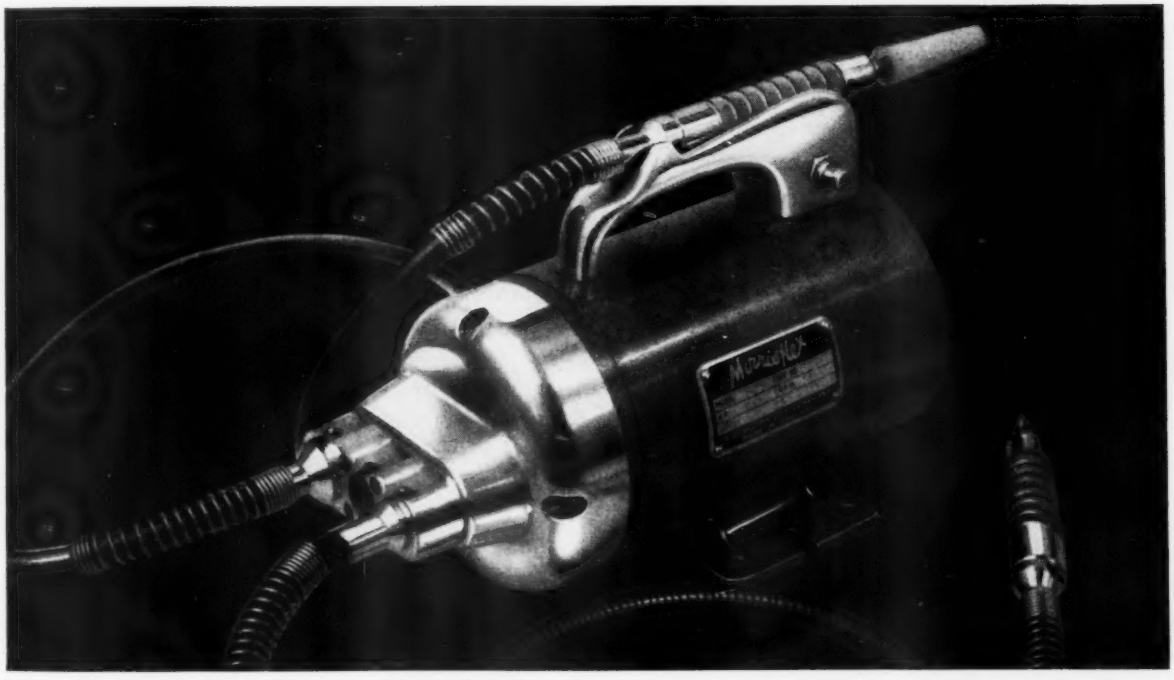
Material B.S.1503/151—1950, grade B, having excellent welding properties, with Charpy V notch impact results of 25 ft. lbs. average at − 10°C.

The Darlington Forge Ltd DARLINGTON

INTRODUCING THE *NEW*

Morrisflex 300

FLEXIBLE SHAFT MACHINE

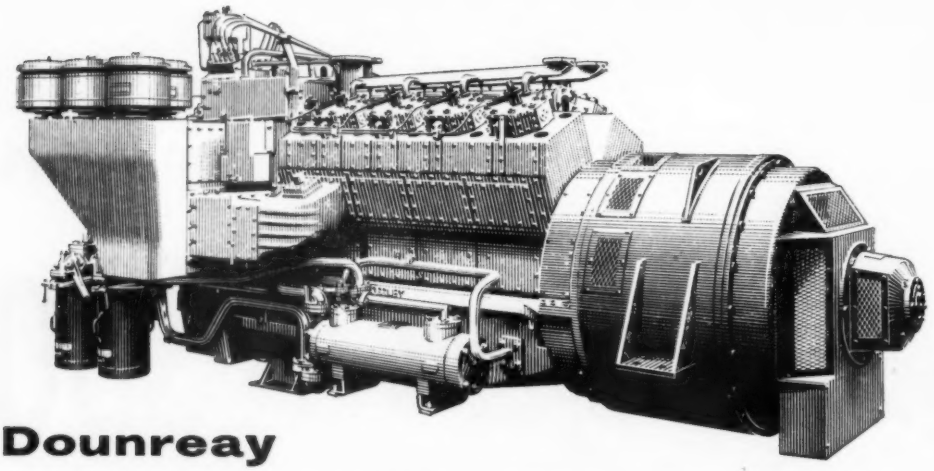


QUICKER SPEED CHANGE
LIGHTER TO HANDLE
EASIER TO MANOEUVRE
FINER FINISH OBTAINED

The M300 is an entirely new machine specially designed for use in the tool room and in all cases where finish is of paramount importance. Optimum speeds are available for cutters in steel or carbide.

Details from

B. O. MORRIS LTD., MORRISFLEX WORKS, BRITON ROAD, COVENTRY. TELEPHONE: 53333 (P.B.X.)



At Dounreay

Crossley Diesels drive these

Versatility and reliability, these are the qualities demanded of the diesel plant and at the United Kingdom Atomic Energy Authority's nuclear power station at Dounreay for the widely differing duties carried out by the 34 Crossley Scavenge Pump two-cycle diesel engines.

MAIN GENERATOR HOUSE—FAST REACTOR

Twenty "ESL" five cylinder engines, rated at 200 b.h.p. at 600 r.p.m., driving 120 kW Bruce Peebles alternators and six "ES Vee" eight cylinder engines, rated at 360 b.h.p. each at 600 r.p.m. driving 220 kW Bruce Peebles alternators.

STANDBY SETS FOR MATERIALS TESTING REACTOR

Three "ESL" five cylinder engines, rated at 200 b.h.p. each at 600 r.p.m. driving 120 kW Bruce Peebles generators and arranged for automatic starting.

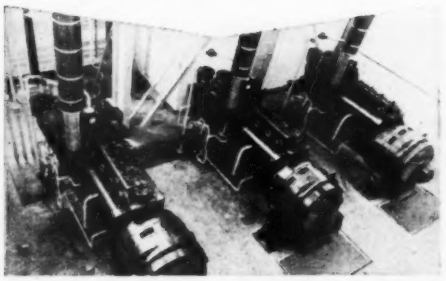
SEA-WATER PUMP HOUSE, FAST REACTOR

Four "ESN" eight cylinder engines, rated at 320 b.h.p. at 600 r.p.m., each driving a Gwynnes vertical spindle centrifugal pump.

FAN VENTILATION HOUSE

One "ESN" three cylinder engine rated at 192 b.h.p. at 960 r.p.m. arranged to start up automatically on mains failure and take over without interruption of of the ventilation system.

Crossley Scavenge Pump Diesel Engines are also installed for vital duties in nuclear power stations at Calder Hall 'A' and 'B'; Chapel Cross; Berkeley; and Bradwell.



these

and these

CROSSLEY DIESEL ENGINES

CROSSLEY BROTHERS LIMITED · OPENSHAW · MANCHESTER. 11

C434/r

To meet demands from the petroleum, chemical and nuclear industries, Hayward Tyler have introduced a new range of glandless motor pump units. These will handle costly, corrosive, and dangerous liquids, without leakage loss, at system pressures up to 3000 P.S.I. and at temperatures up to 750°F. The units are weatherproof, self-aligning, self-lubricating, and self-maintaining for many thousands of hours.

HAYWARD TYLER

& CO LTD. P.O. BOX 2, LUTON PHONE : LUTON 6820

LONDON OFFICE: SALISBURY HOUSE, FINSBURY CIRCUS, E.C.2. NATional 9306-9

Circle **No 65** on reply card for further details

SHOPPING FOR NUCLEAR FEED MATERIALS?

Whatever your reactor material needs may be, the Davison Division of W. R. Grace & Co. has a complete selection of uranium or thorium metals and oxides. Look to Davison for assistance with A. E. C. licensing, shielding assemblies and scrap recovery. Contact Davison now for complete information.

Natural or enriched . . . powder, pellets, rods, ingots, buttons or derbies . . . in precise grades . . . in all enrichments . . . highest purity . . . now supplied by Davison in tonnage quantities.

DEPARTMENT B-09

W.R. GRACE & CO.

DAVISON CHEMICAL DIVISION

ERWIN, TENNESSEE

Circle **No 66** on reply card for further details

WALKER'S 'LION' CHEVRON & TWINSET

Packings on 4,500 ton press

Walker's packings are used throughout a 4,500 ton hydraulic plate press at Whessoe Ltd., Darlington. Possibly the largest of its type in the world, it was designed specially for the shaping of spherical pressure vessels for atomic power stations. The pressure vessels (made from well over 1,000 tons of steel) have walls up to 4 inches thick which are pressed from plates weighing up to 10 tons.

The illustration above shows this giant plate press built by Messrs. Fielding & Platt.

Free technical literature on Walker's 'Lion' Chevron and Twinset packings, which are giving such outstanding service on all types of presses throughout the world, will be sent on request.

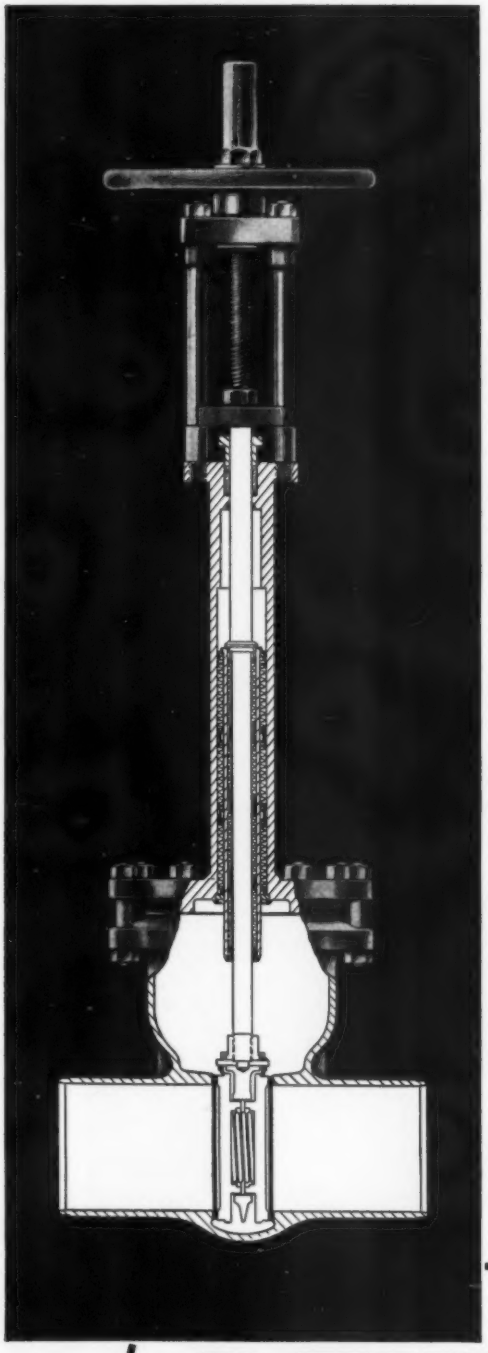
T18.340

James WALKER & CO. LTD.

'LION' WORKS, WOKING, SURREY, ENGLAND

Telephone : Woking 2432 (Telex. 8521). Telegrams : 'Lioncelle Woking Telex'

DEPOTS THROUGHOUT THE WORLD



This is a

FABRICATED GATE VALVE *for* NUCLEAR APPLICATION

It is one of many special valves we have developed for this type of work recently. The body is fabricated from pre-forged parts, and the spindle is

BELLOWS SEALED

A design with over a century's background

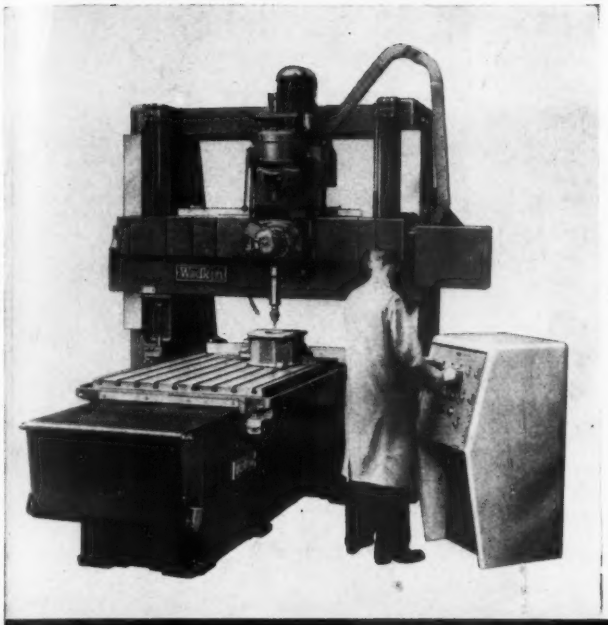
DEWRANCE

LEADERS IN VALVES FOR STEAM AND NUCLEAR APPLICATION

DEWRANCE & *COMPANY LIMITED* — **GREAT DOVER ST., LONDON, S.E.1** — **Telephone: HOP 3100 (12 lines)**

LONDON · BRADFORD
DUMBARTON · HILLINGTON

Circle **No 68** on reply card for further details



ROTAX RECIRCULATING BALL THREADS

Most advanced of their kind -used throughout industry.

Rotax Recirculating Ball Threads are over 90 per cent efficient. All ball threads and nuts are completely reversible, but locking devices can be supplied if required. Stabilised and made of special materials, they remain accurate indefinitely. 'Clean' nuts simplify fitment.

SPECIFICATION.

Operating load.....up to 80,000 lb.
Standard Shaft length.....up to 20′
(Longer lengths can be supplied for specific applications.)

Standard Pitches.....·200″ ·218″ ·250″ ·500″
(Non standard pitches can be supplied.)
Shaft diameter.....up to 4″
Life.....10,000,000 reversals
Temperature range.....−90°C to +100°C
(using special materials, temperature range can be extended up to +950°C.)

APPLICATIONS

Machine Tools, Printing Industry, Instruments, Industrial Valve Control, Missile Control Systems, Nuclear Engineering, Wind Tunnels, and many others.

If you would like information on Rotax Recirculating Ball Threads, Linear Way Bearings, Switch gear, Compressors, Level Crossing Barriers, Electric or Pneumatic Motors, please write or telephone:

ROTAX

INDUSTRIAL GROUP, ROTAX LIMITED

WILLESDEN JUNCTION, LONDON, N.W.10 (ELGar 7777)
LUCAS-ROTAX (AUST.), PTY LTD., Melbourne and Sydney, Australia.
LUCAS-ROTAX LTD., Toronto, Montreal and Vancouver, Canada.

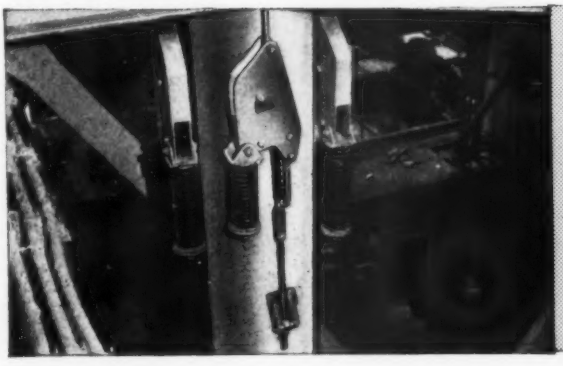
Circle **No 69** on reply card for further details

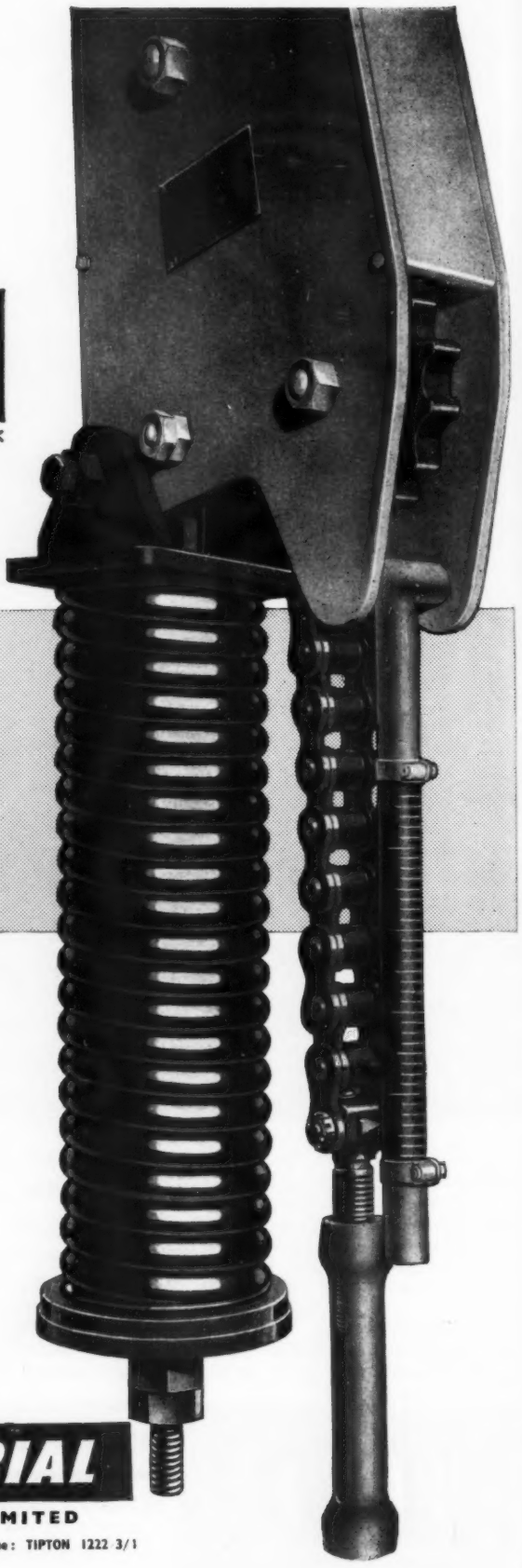
For controlled pipe movement . .

CON-TEN

REG. TRADE MARK

CONSTANT TENSION PIPE SUPPORTS





The Con-Ten system has not only been tested, but *proved* in industries and power stations all over the world. No matter what the load or the pipe movement, or the problems met, there is a Con-Ten to provide the most adequate and *permanent* support available. Loads from 100 lbs. to 14 tons and pipe movements up to 18" can be controlled by constant tension supports in the Con-Ten range.

Contact us now for full information.

British Patent Nos. 474008, 720074, 720075, 697987, 816976, U.S.A. Patent No. 2129320.

BRITISH INDUSTRIAL

ENGINEERING COMPANY (STAFFS) LIMITED

CORONATION WORKS, HAINGE ROAD, TIVIDALE, TIPTON, STAFFS. Telephone: TIPTON 1222 3/1

IN THE MAKING

In common with other Worthington-Simpson products, our condensing plant is manufactured with precision from the highest quality materials and is designed to give long and reliable service.

Specialists in the Worthington-Simpson organisation deal with all problems of heat exchange. We have considerable experience in producing condensing plant for high vacua and feed systems operating at the highest pressures and temperatures.

Complete systems are designed, manufactured, erected and installed, including auxiliary plant—condensers, air ejectors, feed heaters, evaporators, de-aerators, fuel oil heaters, and water coolers for both land and marine installations.

Worthington - Simpson Ltd.

NEWARK NOTTS

WS

PUMPS · COMPRESSORS · HEAT EXCHANGE EQUIPMENT

P.4229

the unique SAFETREAD resistance welding method cuts corrosion

"Safetread" steel flooring is *homogeneously resistance welded under pressure*—thus closing the grain of the material and providing a highly corrosion-resistant joint of great strength. "Safetread" floors installed for many years under rigorous conditions show that the least corrosion has taken place at the point of welding. Welded through the neutral axis of the main bar, maximum strength and lateral stability is also gained.

Engineers everywhere specify "Safetread"—its unique design and construction give greatest strength and rigidity with a minimum of weight which enables valuable economies to be effected in supporting members. "Safetread" is tailor-made to your specification no matter how intricate the layout. **WRITE TO-DAY** for the "Safetread" catalogue—it's a mine of information including deflection tables, safe load tables, etc., a valuable work of reference for the man with a flooring problem.

SAFETREAD

WELDED STEEL FLOORING

ALLAN KENNEDY & CO. LTD., MARITIME STREET, STOCKTON ON TEES

Tel: Stockton 65464 (4 lines) Grams: 'Grating' Stockton on Tees. London Office: Abford House, Wilton Road, S.W.1. Tel: VICtoria 2539

P4895

RIO TINTO

Rio Tinto, producers of uranium and thorium, will play an important part in the future industrial use of nuclear power through the following companies:

Rio Algom Mines Limited, CANADA
will amalgamate the four Canadian uranium mining companies under Rio Tinto's management to form the largest uranium producing company in the world.

Thorium Limited, UNITED KINGDOM
owned by Rio Tinto and Dow Chemie A.G., processes crude thorium materials and markets a variety of refined thorium and rare earth compounds.

Mary Kathleen Uranium Ltd, AUSTRALIA
managed by Rio Tinto in Australia, is now in full production and supplying uranium oxide for Britain's nuclear power stations.

Nukem-Nuklear-Chemie und-Metallurgie G.m.b.H., GERMANY
has been formed by Deutsche Gold-und Silber-Scheideanstalt (Degussa), Rio Tinto and Mallinckrodt Chemical Works to manufacture nuclear fuel materials and fuel elements.

Rio Tinto Dow Limited, CANADA
Rio Tinto and the Dow Chemical Company of Canada are collaborating in uranium processing and producing thorium as a by-product of uranium.

Austro-Chematom Kernbrennstoff G.m.b.H., AUSTRIA
formed by Osterreichische Stickstoffwerke A.G. in association with Rio Tinto and Degussa to manufacture nuclear fuel materials and fuel elements.

Rio Tinto Management Services (U.K.) Limited
BARRINGTON HOUSE, 59 GRESHAM STREET, LONDON, E.C.2

Safe Conduct

A PLESSIFLEX application on the Bristol Bloodhound

Tough, flexible, seamless, all-metal PLESSIFLEX is the most thoroughly reliable means of conveying fuels and chemicals—whether they are gases or liquids, very hot or very cold, corrosive or inflammable—from one place to another. And this point is overwhelmingly endorsed by engineers in the aeronautical, nuclear, marine and chemical industries.

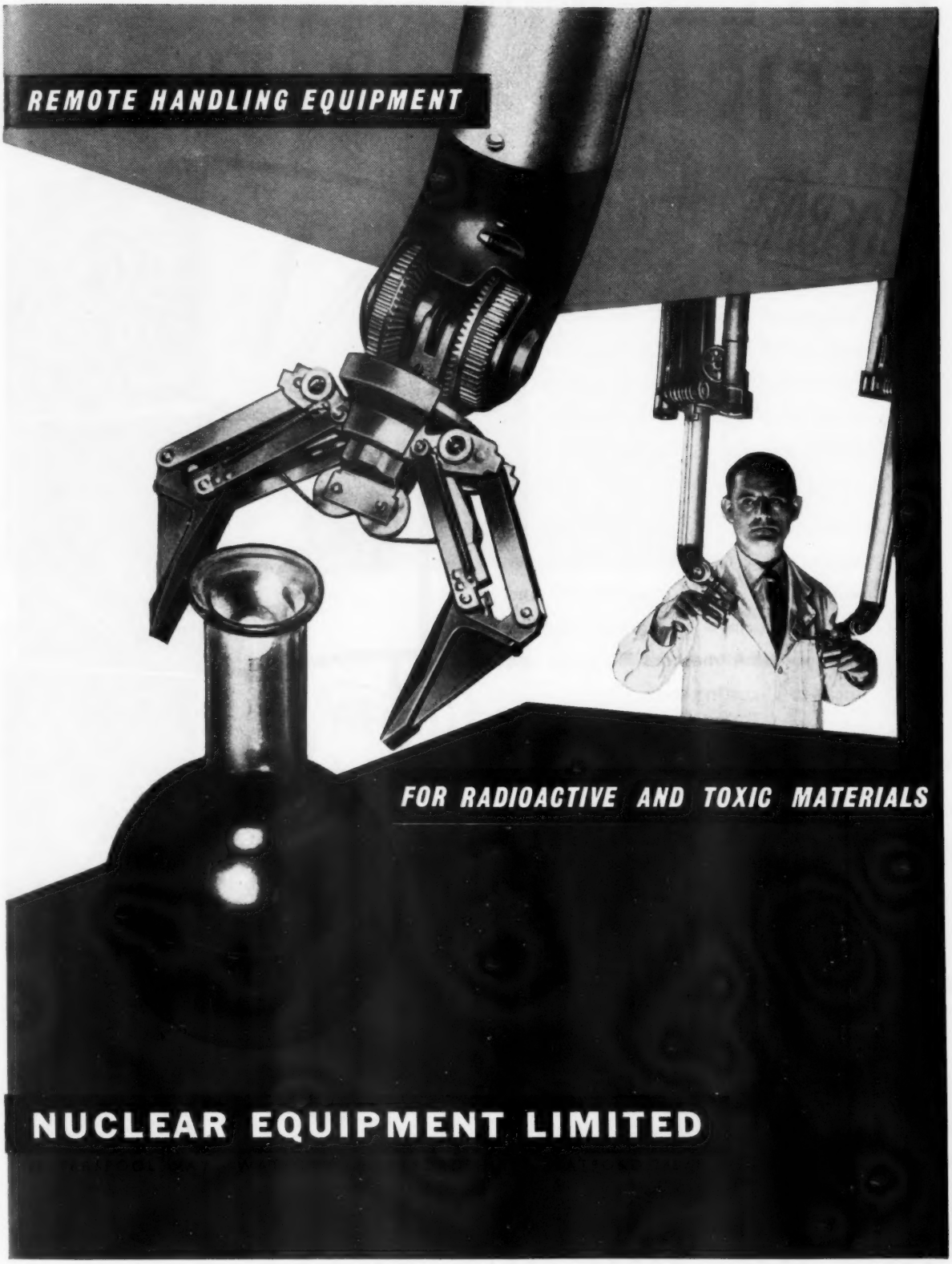
At pulsing pressures, at high pressures or under vacuum conditions, PLESSIFLEX provides the vital link between those parts in your installations which are subject to continual relative movement.

The basic components of PLESSIFLEX are the result of continuous development and testing, in consequence of which the complete hose units are unrivalled in their high quality. Offered in a range of sizes from $\frac{1}{8}$" to $2\frac{1}{2}$" bore, and in almost any metal you care to name, PLESSIFLEX may be tailored to *your* particular requirements.
Suitably braided for stability, the tube itself is made from material that has been subjected to rigorous pre-process analysis—everything in fact about this versatile, incredibly robust product is shaped to the ends of higher performance and greater safety in fields where such requirements are essential.

Our engineers are waiting to show you how PLESSIFLEX Regd. Trade Mark **can solve your piping problems**

POWER AUXILIARIES LIMITED · Kembrey Street · Swindon · Wilts · Tel: Swindon 6211
Overseas Sales Organisation—Plessey International Limited, Ilford, Essex Tel: Ilford 3040

PAL14c



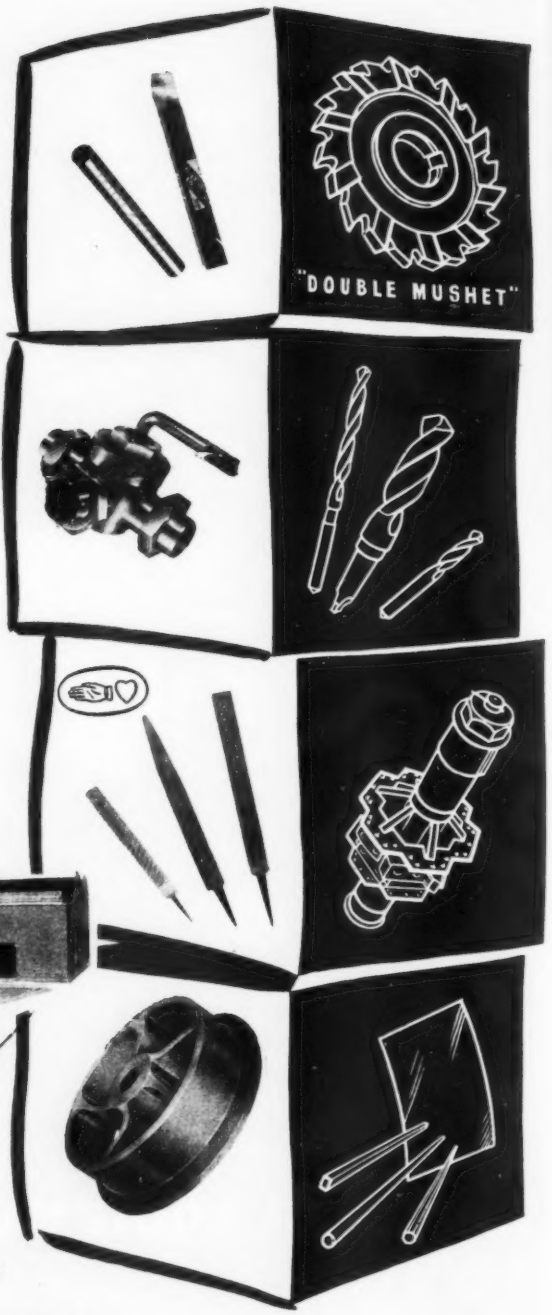
Circle **No 75** on reply card for further details

BUILD YOUR EFFICIENCY WITH

OSBORN PRODUCTS

Integrated experience from over a century of craftsmanship has made the name of *Osborn* world-famous as a hallmark of quality in the manufacture of fine steels and steel products.

Products in alloy, stainless and tool steels are manufactured throughout within the same organisation, and include castings by general foundry and precision methods, forgings and engineers' cutting tools.



STEELMAKERS · STEELFOUNDERS · ENGINEERS' TOOLMAKERS

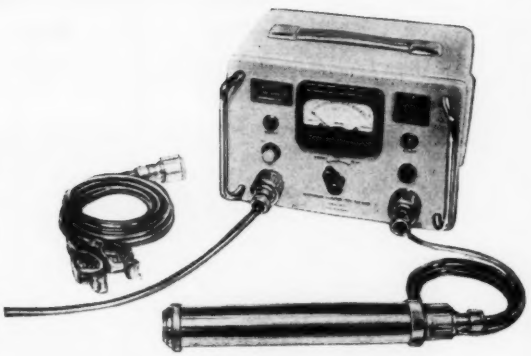
SAMUEL OSBORN & CO., LIMITED

CLYDE STEEL WORKS, SHEFFIELD

Plessey

Radiation Monitors and Detectors

Growing acceptance of the radiation monitor and detector devices developed by Plessey Nucleonics Limited establishes their overall superiority. Indeed, the PNL instruments illustrated here offer substantial improvements of robustness and convenience of application over the type available hitherto.

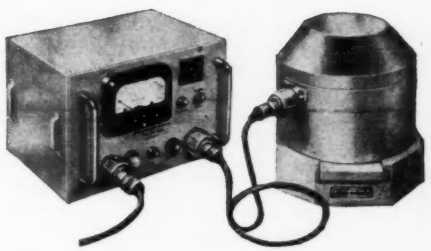


Selective Gamma Monitor type 1080
—Publication No. PNL 111

PNL programmes for nucleonic development

PNL is engaged in the design and manufacture of standard and specialised nuclear instrumentation—burst fuel element detectors for reactors, flux scanning equipment, radiation detectors of all types, process control instrumentation, health and defence instruments.

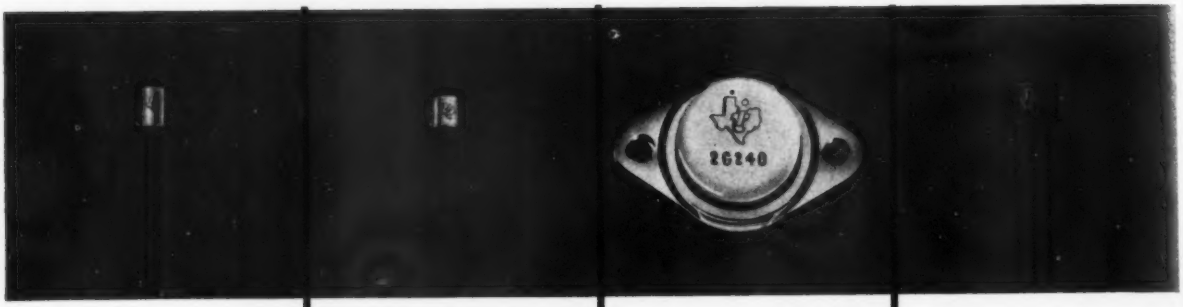
The parallel production by PNL of so much that is complementary in nuclear instrumentation has established within the Company a unique bank of scientific skills and techniques, which is now offered for the development of new projects. The Company's liaison engineers are freely available to assist with problems in their field.



General Purpose Contamination Monitor type 1065
—Publication No. PNL 112

PLESSEY NUCLEONICS LIMITED • WEEDON ROAD • NORTHAMPTON
Telephone: Northampton 4966 • One of the Plessey Group of Companies
Overseas Sales Organisation: Plessey International Limited • Ilford • Essex • Telephone: Ilford 3040

COMPUTER TRANSISTORS FROM TEXAS



FOR MEDIUM SPEED COMPUTERS	FOR FAST COMPUTERS	FOR CORE DRIVING	FOR CORE DRIVING
(up to 1 Mc/s digit rates)	(up to 50 Mc/s digit rates)		
2G301 • 2G302	2N711	2G240	2N696 • 2N697
2G303 • 2G304	2G103 • 2G104	I_C=3A V_{CB}=80V	f_1=40 Mc/s (min)
High Frequency. High Current	50mA · 300 Mc/s	f_1=15 Mc/s (min)	I_C=500 mA

FOR ALL COMPUTERS - TEXAS

Write for Data Sheets & Applications Information on these and other Texas semiconductor devices which include

NPN SILICON TRANSISTORS Signal · U.H.F. · Power
GERMANIUM TRANSISTORS U.H.F. · Power
SILICON RECTIFIERS & DIODES High Voltage · Signal · Computer · Photo · Zener
SILICON ZENER VOLTAGE REGULATORS
SILICON CONTROLLED RECTIFIERS
SEMICONDUCTOR-GRADE SILICON

TEXAS INSTRUMENTS LIMITED

DALLAS ROAD BEDFORD ENGLAND
BEDFORD 68051 CABLES: TEXINLIM · BEDFORD

91/A26

Nuclear Power
REACTORS · MATERIALS · INSTRUMENTATION · PROCESSES · IRRADIATION

SEPTEMBER 1960 VOLUME 5 NUMBER 53

VIEWPOINTS *letters to the Editor*

Teaching reactors

SIR: In his eagerness to discredit the research and training reactor as a University tool, Dr. Scurlock makes statements in your June issue which I find a little misleading. The impression given to me is that a 100 kW reactor is quite unsuitable for work on shielding and on radiation damage. Harwell's reactor Lido at 100 kW [illegible] built specifically for shielding [illegible]ives the answer to the first [illegible] for radiation damage, the [illegible]mage to semi-conductors, [illegible]ly to be of increasing [illegible]tainly suitable for 100 kW [illegible]d to use very high flux re[illegible]ld be a case of using a sledgeh[illegible]o crack a nut. When the study [illegible]ns mechanisms of damage ra[illegible]han the testing of components, [illegible]very high fluxes may not be as vi[illegible]s Dr. Scurlock suggests.

However, [illegible]erms of the general discussion o[illegible] University reactors, these are fai[illegible] small points and, moreover, I do not wish to argue against universities having facilities better than the 100 kW one. In any event a sound technical case will surely have to be presented to a competent body by any university wanting a reactor; the fact that these machines are available commercially does not mean that they will be handed out on request.

The disadvantages which Dr. Scurlock indicates will have to be taken into account but the final judgment must rest on the overall picture and not just on the view of individual items such as training alone, physics research alone, which is presented in his letter. After all, the *combination* of training and research in several disciplines has value in itself.

Physics Department, University of Birmingham — J. WALKER

Research reports

SIR: We were pleased to read in the *Students' Notebook* section of the May issue the account of *Nuclear Science Abstracts*. This journal is one of the most important single publications of this organization and we are striving to make it recognized and used by scientists the world over as a means of keeping abreast of the literature of nuclear science. Your article, and others like it, certainly help.

There was one statement in your article to which I would like to take exception however. This statement is quoted as follows: 'In common with most published abstracts, NSA is some months behind but many of the AEC reports do appear, in listed form only, far sooner in the official *US Government Research Reports*.' We made a random check of 22 reports prepared by a representative group of AEC contractors listed in six issues of *US Government Research Reports* from January through May 13, 1960, and compared this record against appearance of abstracts in NSA. From this random sampling we cannot agree with the statement quoted above for it showed earlier appearance in the latter journal by as much as four to five months in some cases.

US Atomic Energy Commission Office of Technical Information, Tennessee — PAUL E. POSTELL, CHIEF CATALOGING BRANCH, OFFICE OF TECHNICAL INFORMATION EXTENSION

Marine Organic Moderated Reactors

SIR: I wish to comment on a short report of a paper read to the Institution of Naval Architects printed on page 88, in your May 1960 issue of NUCLEAR POWER. The quotations are entitled 'Bleak Future for Marine Organic Moderated Reactors' and indicates that the OMR can be ruled out as a long term marine project because of:

1. Coolant temperature being limited to 692°F
2. Fire risks
3. Liquid waste disposal problem.

I wish to say that as far as temperature limits are concerned, the 692°F limit which was quoted is higher than any temperature which has been considered for a pressurized water reactor. Even so, this temperature is incorrect. The limiting temperature of terphenyl coolants is on the order of 850°F where the pyrolytic polymerization rate begins to become significant. With a bulk coolant temperature of 750°F fuel element surface temperature of as high as 900°F can be utilized. At a temperature of 692°F, the polymerization of the organic material is due almost entirely to radiolytic effects.

Concerning fire risks, the flash and flame points for the organic coolant material are on the order of 450°F, hence the material will burn. However, adequate protection is afforded by use of flame-proof electrical equipment as well as standard fog-nozzle fire fighting systems. In our work with polyphenyl coolants over the last seven years, including operation of the OMRE over the last two, we have not encountered any serious fires.

Because of the polymerization of the organic coolant, the polymerization products in the coolant must be continually removed and new coolant added. These high boiling point materials are then burned in a conventional fire-tube boiler so that, aside from the combustion products which are normally vented to the stack, little additional waste remains.

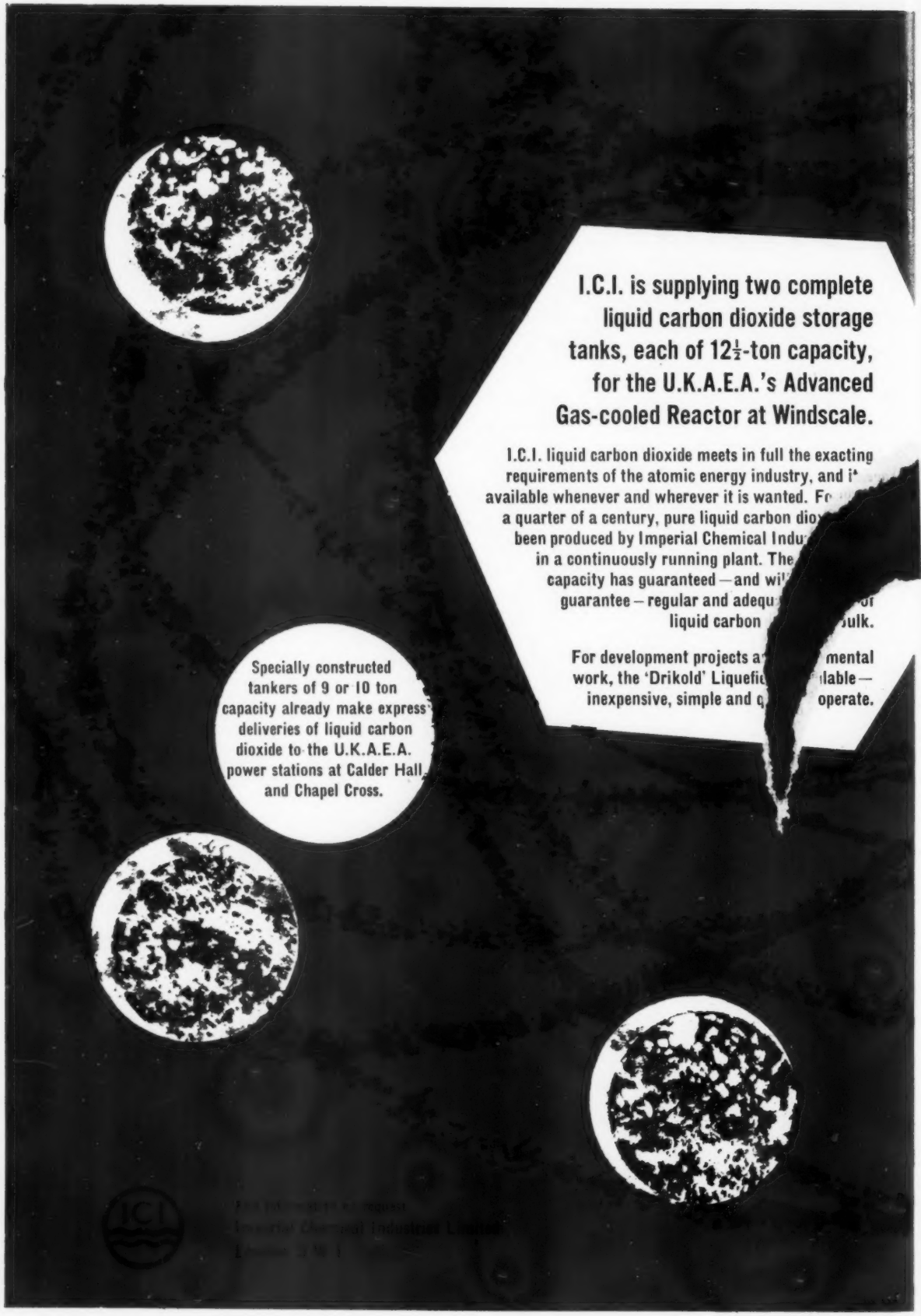
The plant does have facilities for handling liquid wastes; however these wastes are the same as are encountered in other types of reactor plants.

Atomics International Canoga Park, California — R. J. GIMERA, SUPERVISOR NUCLEAR UNIT, ORGANIC REACTORS DEPT.

Isotope use

SIR: You are far too optimistic in your July editorial about industry increasing its use of isotopes. The enlightened firms will, no doubt, have them already at work and will be thinking of further applications. But the majority, in my experience, conservative to the core, are unlikely for many, many years to do so—in spite of the UKAEA's new Isotope Information Bureau.

Croydon, Surrey — D. I. JOHNSTON


I.C.I. is supplying two complete liquid carbon dioxide storage tanks, each of 12½-ton capacity, for the U.K.A.E.A.'s Advanced Gas-cooled Reactor at Windscale.
I.C.I. liquid carbon dioxide meets in full the exacting requirements of the atomic energy industry, and i
available whenever and wherever it is wanted. Fo
a quarter of a century, pure liquid carbon dio
been produced by Imperial Chemical Indu
in a continuously running plant. The
capacity has guaranteed—and wi
guarantee—regular and adequ
liquid carbon
ulk.
For development projects a
mental
work, the 'Drikold' Liquefi
ilable—
inexpensive, simple and q
operate.
Specially constructed tankers of 9 or 10 ton capacity already make express deliveries of liquid carbon dioxide to the U.K.A.E.A. power stations at Calder Hall and Chapel Cross.
ICI

OPINION

More international agencies

FOLLOWING quickly upon US disappointment over the virtual collapse of the first phase of the two year old US-Euratom $M450 programme, Robert McKinney's recent report to the Joint Committee on Atomic Energy (see *Worldview* this issue) has enlivened the American atomic energy scene. It has also brought American nuclear foreign policy into sharp focus. Because US objectives overseas have not resulted in any substantial achievement, a re-orientation of research towards 'truly low-cost nuclear power' is recommended. For this purpose, collaboration with other progressive nuclear countries is proposed; the report recommends establishing two new international bodies—a Coucil of Atomic (Energy Commission) Chairmen and a subordinate Conference of Atomic Labratory Directors.

Setting up new international organizations is always a matter for caution; with an International Atomic Energy Agency already at work and a very active European Nuclear Energy Agency (ENEA) programme under way, this proposal is due for fire from many directions. There can be no argument about the desire to avoid wasteful duplication in costly research; this has already been reduced in Europe by ENEA through its Halden and Dragon projects and by the development of the Eurochemic plant. The work at CERN and the recently proposed Euratom participation in the Hamburg OMR ship programme are additional examples of successful international cooperation. With the entrance of the United States and Canada into the reconstituted OEEC, the Organization for Economic Cooperation and Development, it is to be assumed that these two countries will have more to say in ENEA activities. They can also be expected to take part in its projects. This will raise ENEA's international status and provide a forum where national programmes can be discussed and coordinated.

In all these cooperative schemes, the close liaison between heads of atomic commissions and of the research laboratories is already an established practice. Why then is it necessary to set up additional organizations to direct supranational research work when this is already being done successfully? The report itself suggests that there should be closer liaison with Euratom, ENEA and the IAEA. Surely this would be enough?

The key to the reasons may well be two: the American anxiety that the International Atomic Energy Agency might become unworkable through political obstruction on the part of one or more of the major powers, an attitude borne of bitterness over clashes in the field of international politics. Indeed, the ENEA is to be considered, says the report, as an alternative channel should the Agency fail in its objectives. The second reason could be fear that European cooperation schemes will lead to quicker advance on a narrower front and leave the US behind.

It is true the IAEA has not achieved all it could have done in its three years of existence. But is this fault not to be laid at the door of the United States who could perhaps have provided more imaginative and comprehensive support?

The IAEA should not be allowed to fail, however, for there are problems to which only this body can attempt to find satisfactory solutions. Apart from the urgent task of forming internationally accepted standards for safety from radiation hazards, there is no substitute for its role as a forum for world opinion on the many facets of nuclear power development for peaceful uses. Neither is there one for its role in seeing that materials are not diverted to military uses. Supranational organizations always have had difficulties combating ideas of national sovereignty but one can point to quite a number of successes on the part of specialist agencies, WHO and UNESCO, to mention only two.

Valves in atomic energy

AS INDUSTRIAL concerns do not broadcast their difficulties and failures, the amount of sheer engineering know-how that goes into building a nuclear power station is often too little appreciated except by those who have tried it. In poring over studies of various reactor systems to decide on a future nuclear power project, governments are therefore liable to assume that when the economics look right, and the money and fuel is available, they can build up an industry in quite a short space of time.

In fact, the resourcefulness and skill of their industries will be stretched to the utmost in overcoming countless problems of engineering—many in themselves very small and detailed—and it is the speed with which these are solved that will determine the pace of a programme.

Among the ordinary components which have to be developed to answer to stiffer specifications are valves, and in this issue, NUCLEAR POWER publishes several articles on the subject. Some of the firms listed in the *Buyers Guide* deserve special praise for their foresight in tackling special problems, even when only very short runs are involved and the profits doubtful. They are willing to devote a part, at least, of their efforts to the most difficult and advanced types, such as some of those required in atomic energy work, instead of concentrating entirely on mass production of standard items.

It is interesting to note in this connexion that, while international trade in valves of all types has almost doubled in the last ten years, there is a marked tendency for the simpler types to be manufactured locally by developing countries. The growth in demand for the more complex valves, on the other hand, shows no sign of slackening.

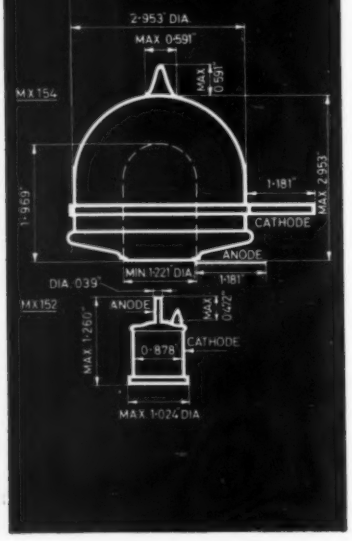
UNIQUE LOW BACKGROUND BETA COUNTING ARRANGEMENT

This unique low background counting arrangement requires shielding weighing less than 500 lbs. Under such conditions background count rate is below 1 count per minute while beta sensitivity is greater than that of all other Geiger Müller tubes of comparative size. Two sizes of beta end window tube with their appropriate guard tubes are available. Write to-day for further details.

Mullard

X-RAY DIVISION

Mullard Limited,
New Road,
Mitcham Junction,
Surrey,
England.
Tel: Mitcham 3471



MXR 517

Circle **No 81** on reply card for further details

WORLDVIEW

the month in atomic energy

EUROPE

Franco-Belgian group orders PWR station

Brussels A 242 MW closed-cycle pressurized water reactor plant, designed by Westinghouse Electric Corporation of the US, is to be built at Chooz, near the Belgian-Franco border. The contract was placed by SENA (Société d'Energie Nucléaire Franco-Belge des Ardennes) and is worth $M70–80. Euratom has designated the project as a 'common enterprise'.

Some complications may arise before final details are settled, *Nuclear Power* understands. These concern the assurance of an adequate fuel supply, insurance stipulations and financial support from the Belgian government. This last item has been promised in principle but the financial repercussions of the Congo crisis may hold up a final Belgian decision.

Equipment for the plant, which is scheduled for operation in 1965, will be manufactured by Westinghouse, Atéliers de Constructions Eléctriques de Charleroi of Belgium and Framatome of France and a number of their affiliated companies. When finished, the SENA plant will be the largest single-reactor plant in Europe using enriched uranium, says Westinghouse. The US company is also supplying equipment for the SELNI plant in Italy.

The award followed Euratom's agreement that SENA should be given the status of a joint enterprise. This means that it will benefit from a series of fiscal and customs advantages, including exemption from the payment of direct taxes. Technical and economic informations resulting from the construction and exploitation of the plant, on the other hand, must be made known to the Euratom Commission.

SENA is an association of French and Belgian utilities with half the capital coming from the Belgian group Centre et Sud. The remainder comes from Electricité de France (EDF). These two groups proposed a 150 MW plant when the US-Euratom invitation was issued in the early part of 1959 but in the autumn decided in favour of a larger plant because a study made showed that costs would be lower.

Turriff's start work on 'Dragon' reactor building

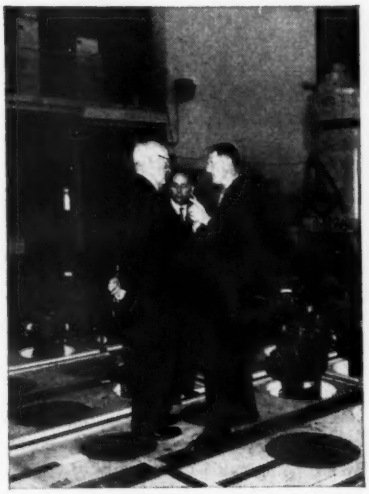
London Work on the reactor building for the OEEC 'Dragon' project has been started by Turriff Construction Corp. Ltd., who have been awarded the main civil engineering contract, valued at over £M1, for the whole project. A feature of the structure will be a 'leaktight' concrete outer wall and roof—a condition normally obtained by using welded steel. Completion is scheduled for 1963.

Meanwhile, progress on the Dragon high temperature gas-cooled reactor project as a whole is described in the first annual report which says research facilities in seven countries are being used to help with development difficulties.

Site chosen for Welsh station

London Speculation about the site of the next nuclear power station in North Wales has been ended by the Central Electricity Generating Board's announcement that they have chosen Wylfa Head on the north coast of Anglesey. However, the revised nuclear power programme means a station at Wylfa will not be required before 1966; construction is therefore unlikely to begin before 1963 at the earliest.

• **United Kingdom** The UKAEA is to buy a Stretch class computer from IBM United Kingdom Ltd for installation towards the end of 1961. The AEA has a large-scale IBM 709 computer in use.



SENATOR SPOONER AT CALDER HALL
The Australian Minister for National Development, Senator W. H. Spooner (left) talks to Mr. E. Desbruslais, Works Manager (centre) and Mr. T. Tuohy, General Manager, on the charge floor of No. 4 reactor, during his recent UK visit

Tenders received for Swedish boiling water reactor

Stockholm Two Swedish-US groups have submitted tenders to build a 50 MW boiling water reactor, moderated and cooled by light water, for a power station to be built on the Simpevarp peninsula, about 20 miles northeast of the town of Oskarshamm. They are the Swedish companies ASEA and NOHAB in collaboration with International General Electric, and Allis Chalmers and the Swedish firms Kockums Mekaniska Verkstads AB and AB Tekniska Byggnadsbyram.

The proposals are being evaluated and are expected to be completed before the end of 1960. They were sent in as a result of an invitation issued at the end of 1959 by AB Atomkraftverk (AKV), an AKK Atomic Power Group affiliate.

AKV has asked for a government licence to build and operate the proposed station whose site was chosen so that additions could be made to bring the capacity within the 500 MW range.

WORLDVIEW

Dungeness cost is £110/kW — Hinton

London The cost of the Dungeness station will be £110/kW, Sir Christopher Hinton, chairman of the Central Electricity Generating Board, revealed in his recent Royal Society Tercentenary lecture. In his opinion, economies in layout and general engineering will bring the capital cost of 500 MW Calder Hall type stations down further but he estimated £100/kW as the limit of the reduction; this would give a generating cost of around 0·52d/unit.

His lecture, 'The Evolution of Nuclear Power Plant Design' adds that the initial generating cost estimated for the Advanced Gas-cooled Reactor showed little, if any, immediate advantage on the Calder reactor; it was probable, therefore, that there would be a period in which orders for AGR stations would be interspersed with orders for Calder type stations. This could continue until the AGR showed a clear operating cost advantage over the older type and would conform with practice in the conventional field. It was possible that the number of AGR stations the CEGB would build, would be less than ten.

Sir Christopher illustrates the downward trend in cost of nuclear power plants being built by the CEGB by the following table :

Station	*Capacity (MW so)*	*Cost (£/kW so)*
Berkeley	275 (2 reactors)	160
Hinkley Point	500 „ „	133
Bradwell	300 „ „	160
Trawsfynydd	500 „ „	123
Dungeness	500 „ „	110

This downward trend represented growing familiarity with problems of design and construction and better overall optimisation of design. Three distinct lines of advance could be seen: an increase of pressure in the gas circuit; improved utilisation of pressure volume and increase in fuel element and coolant temperatures.

All these developments helped the designer to move in the direction of obtaining more power from a given size of reactor and to achieve a lower capital cost per kW. These results could be assessed in terms of reactor heat generated per unit volume of core. Sir Christopher sets out these 'heat densities' as follows:

Station	*Heat Density*	
	kW/cu.ft of core	kW/cu.ft of pressure vessel
Berkeley	10·21	4·46
Bradwell	10·77	3·37
Hinkley Point	15·09	6·13
Trawsfynydd	17·46	7·31
Dungeness	15·37	6·73

Sir Christopher added that it was disquieting to compare the research and development effort devoted to bringing down costs in the conventional and in the nuclear field. For the former, available figures suggested that these costs were of the order of 5% of the capital value of power plants built. For the latter, assuming that the cost of the nuclear sections of power plants built for the CEGB from 1965-75 was rather less than £M50/year, it seemed improbable that research and development costs would be less than 30%, if effort were maintained at its present level. As an example, he stated that by the time the AGR goes into use, research and development of the Windscale prototype would have been about £M30—and this was only one part of the effort required.

If the present rate of technological progress continued, there was little prospect that these costs would fall. 'For how long can the electricity industry justify this ?' he asked. It would appear reasonable to continue the high rate of advance of nuclear technology to the point where nuclear power broke even in cost with conventional power. After that date, 'it is surely reasonable to think that research on reactor technology should be justified by savings which can be expected to arise from its industrial application. . . .'

• **Euratom** Scientists from Euratom countries are moving to Ispra, northern Italy, to staff the Community's first nuclear research centre.

• **W. Germany** The research reactor operated by Kernergie, Hamburg, specifically for marine applications, reached its rated power of 5 MW recently.

• **France** Operation of the pile G2 at Marcoule restarted soon after work was stopped recently when a joint in a CO_2 gas line broke.

AEA sells beryllium works to private firm

London The United Kingdom Atomic Energy Authority has sold its beryllium works at Milford Haven to Consolidated Beryllium Ltd who will continue operations on a reduced scale. The reason for the sale, said an AEA spokesman, was that the Authority had sufficient supplies and that industry was well equipped to meet future demand. The price paid for the works was not disclosed.

• **United Kingdom** Hinkley Point nuclear power station is now expected to be commissioned in mid-1963, a year later than originally expected, according to a spokesman from the English Electric, Babcock and Wilcox and Taylor Woodrow Group.

• **United Kingdom** Hawker Siddeley's Jason research reactor has been operated at its full designed power of 100 kW.

• **OEEC** The European Nuclear Energy Agency's convention on third party liability in the field of nuclear energy has been signed by the UK, Denmark, the Netherlands, Switzerland and Luxembourg.

• **Spain** The Spanish Council of Ministers has approved an agreement whereby Spain will join the European Organization for Nuclear Research (CERN).

OEEC sets up Food Irradiation Centre in France

Paris An international centre for food irradiation, the first in the world, has been set up by the OEEC European Productivity Agency and the Centre d'Etude Nucleaires at Saclay. It will encourage closer international co-operation in the development and application of knowledge in that field and serve as a point of contact between private and government concerns.

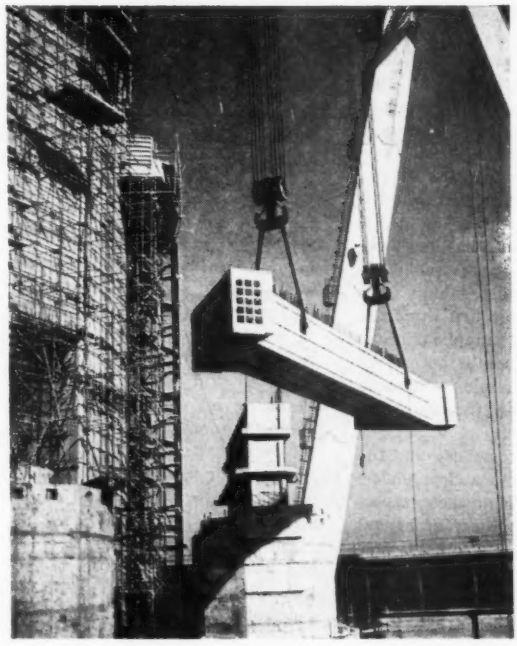
The Centre arises out of the International Conference on the application of Food Irradiation held in July, 1958, by the OEEC/EPA. Subsequent studies led to the setting up of the OEEC Group on Food Irradiation and then to the centre at Saclay.

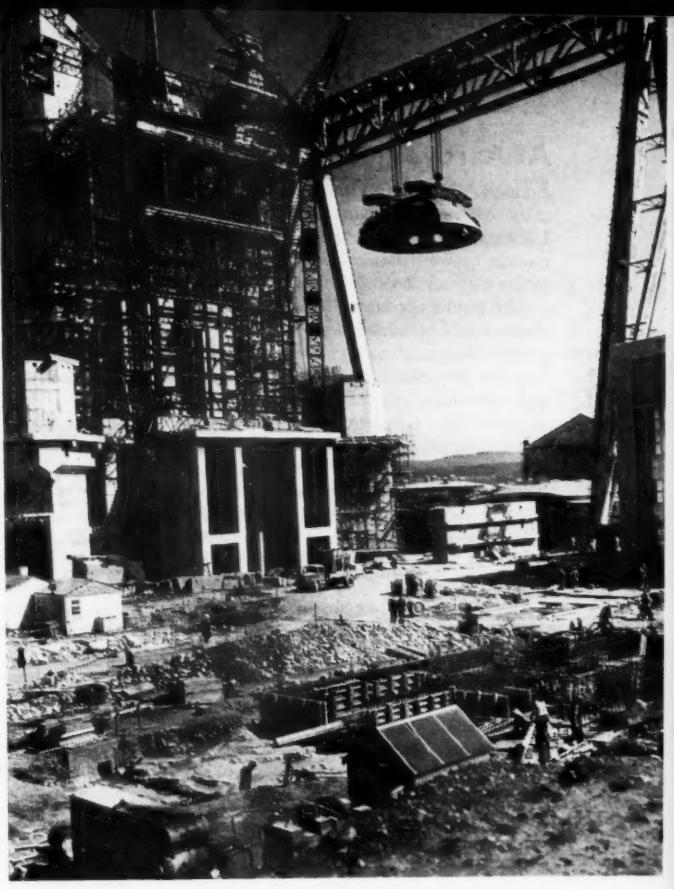
New UK nuclear regulations in force

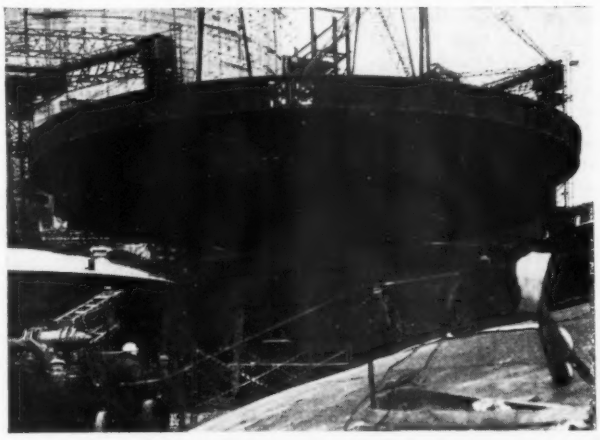
London An extension of the Nuclear Installations (Licensing and Insurance) Act, 1959, covering classes of nuclear installations, apart from reactors, where a hazard could arise if safety precautions were not observed, came into force on August 22 this year. These installations now have to be licensed and the other provisions of the Act, including the provision of cover for the licensee's liability by insurance or other approved means, will apply to them.

The regulations (Nuclear Installations Regulations 1960) cover existing or planned installations, apart from the establishments of Government departments and the AEA, where enriched fuel elements are manufactured or stored. Sites at which fuel elements are stored for research purposes are excluded by these regulations.

Progress at Hunterston —More lifts completed







Good progress is reported by the GEC (in association with Simon-Carves) at Hunterston where several lifts have been completed

1 Our picture (top right) shows the top crown of the reactor pressure vessel being raised by the Goliath crane before being lowered into reactor A

2 One of the 308-ton precast beams (top left) being lifted into position

3 Our final picture (left) shows the core support grid being raised from its fabrication area for placing into reactor A

Minister denies Chapelcross development ban

London No ban has been imposed on future industrial development within a half mile radius of the UKAEA's establishment at Chapelcross. This was stated by the Secretary of State for Scotland, Mr. J. S. Maclay, during his recent visit to the establishment.

Earlier this year, Mr. Maclay had told the Dumfriesshire County Council that applications for future development in the Chapelcross area should be referred to him in the event of a disagreement between the Council and the AEA.

There was no intention to sterilize the area against future development, Mr. Maclay stated. Each application would be considered individually and the decision to call in such cases to himself was to avoid lengthy planning procedure.

Objections were raised earlier this year by the AEA to a proposal to site a chipboard factory close to Chapelcross. This factory is now to be built on a site several miles away.

• **N. Ireland** A survey of coastal sites in Northern Ireland for a nuclear power station has taken place, Mr. James Walker, chairman of the Electricity Board for Northern Ireland reveals in his annual report.

• **Euratom** The Euratom Council wants a rapid conclusion to work being done on a draft complementary convention to that of the OEEC to make provision for civil responsibility in the nuclear field.

WORLDVIEW

AEA royalties agreement needed

London The need to reach a firm agreement on royalty payments between the UKAEA and the Electricity Boards for nuclear power stations is recommended in the Second Report from the Committee of Public Accounts. It says that the absence of agreements after 1965 suggests 'substantial acceptance of the view that the Electricity Boards pay royalties only when nuclear power proves to be economically competitive with conventional sources . . . '.

A quick look at the history of negotiations over royalties is given in the report. It says that in 1956, the AEA submitted proposals designed to produce £M20 by mid-1965 and about £M50 by 1971. The Electricity Boards countered by saying their only concern was to provide electricity by the cheapest means possible. They accepted, in principle, the payment of royalties, but in practice said they should pay only when costs of generation compared favourably with conventional generating costs.

An agreement was eventually reached. The Electricity Boards would pay no royalties on four nuclear stations that were due to be commissioned before 1963. They would, however, pay a royalty for a period of 20 years, on stations due to be completed between 1963 and 1965.

The position changed with the cutback in the power programme and the present situation, says the report, is that the total royalties the Electricity Boards will pay on 'the two stations to be completed between 1963 and 1965 cannot be precisely determined'. But it is estimated it will be equivalent to a lump sum of £M2·5 on completion of each station.

The report also refers to fuel elements and graphite. On the former, the AEA say, the report points out, that they have reached agreement on prices, sufficient to cover costs, including interest, for the initial charges for the first three stations. For subsequent supplies, prices would be fixed three months before the beginning of the year of sale. Agreement on graphite prices for the first five stations has been reached.

The Committee recommends 'that the Authority should come to a clear understanding with the Boards on their respective financial responsibilities for capital expenditure and long-term commitments undertaken by the Authority for supplies for nuclear power programme and that this understanding should be incorporated in firm and binding agreements'.

• **United Kingdom** Mr. John Rodgers, Parliamentary Secretary to the Board of Trade, told the House of Commons recently that it was unlikely that joining Euratom would materially affect the size of the nuclear industry during the next few years.

• **Italy** The Varese (Lombardy) city council has approved the purchase of a 55 sq metre site for the construction of a European nuclear school connected with the Ispra research centre.

UK's uranium stocks may last for ten years

London Enquiries in the House of Commons on the loss the UKAEA will sustain on carrying unused stocks of uranium due to the cut in the nuclear power programme has elicited little further information. Sir David Eccles, the Minister of Education, replying on behalf of the Minister for Science, said the Authority would be carrying large stocks of uranium due to the cutback. The cost of storage was small but it 'is estimated that the annual interest on the capital locked up in the additional stocks may amount to several million pounds'.

Sir David added that present estimates indicated that the Authority's current and prospective uranium supplies might last for about ten years. Their exact duration would depend on factors which could not be accurately estimated at the present time.

• **Germany** About 7½ tons of slightly enriched uranium dioxide fuel, fabricated into 100 fuel elements for the Kahl reactor near Frankfurt, has been shipped from the United States by General Electric's Atomic Power Equipment Department at San Jose, California.

• **IAEA** Discussions are taking place on an agreement for cooperation in the peaceful uses of atomic energy between the IAEA and the Inter-American Nuclear Energy Commission (IANEC).

Gleep gets overhaul

London After being in use for nearly 13 years at Harwell, Gleep (Graphite Low Energy Experimental Pile), Western Europe's first research reactor, has received an extensive overhaul which will increase its efficiency and safety.

During the shut-down, Gleep's instrumentation was completely renewed. The two previous control rooms have been combined into one which commands an extensive view of the reactor and the experimental facilities. Most of the new instrumentation is conventional although transistorized linear and deviation amplifiers have been fitted. (See *Progress in Industry* this issue.)

• **Italy** Elsi Elettronica Sicula SpA, Palermo, is to import 66·38 lb of thorium oxide from the American Potash & Chemical Corporation for the manufacture of electronic tubes.

• **IAEA** More than 75 experts from 19 different countries presented over 50 papers at the IAEA symposium on the effects of ionizing radiation on seeds at Karlsruhe, W. Germany.

• **France.** M. Francis Perrin, the French High Commissioner for Nuclear Energy, said recently that a plan was being prepared for the building of nuclear power stations to be implemened by 1965 when 800 MW from nuclear stations would be available.

Zeta costs given to Parliament

London An insight into the cost of Zeta was given by Sir David Eccles, Minister of Education (representing the Minister of Science), to the House of Commons before the summer recess. In a written reply, he said capital and operating expenditure on experimental work to develop thermonuclear power in Zeta I up to 1960 totalled about £M1·6 including £460,000 for design studies and development work for Zeta II and other future systems.

He added that no capital expenditure had been incurred on Zeta II as the design, development work and studies had shown the necessity for an intermediate current stability experiment (ICSE) for plasma stability studies. It was not certain at this time whether thermonuclear research would lead to economical power. But the rewards of success would be so great that the government considered the present programme fully justified.

Decision soon on UK merchant ship tenders

London A decision on tenders for the building of Britain's first nuclear-powered merchant ship will probably be taken in the next few months, the House of Commons was informed recently by Mr. Ernest Marples, Minister of Transport.

He said a decision could not be made until the tenders had been assessed. 'This was a highly complex task and is bound to take several months', he added. The tenders were received at the end of July.

Italy submits marine project to Euratom

Rome Among the latest developments in European nuclear ship propulsion is the submission to Euratom of a project for powering a 52,000 ton tanker by a water-type reactor of advanced design by the Fiat Company and the Ansaldo Shipyards.

The reactor would be developed in Italy. It is expected that Euratom will provide technical and financial aid for carrying out of the project which would take about two years.

OVERSEAS

McKinney wants more cooperation

Washington The setting up of two new international bodies to help achieve US 'atomic objectives' and co-ordinate national programmes is recommended in Mr. Robert McKinney's report on US foreign policy in the nuclear field. These bodies would be a Council of Atomic Chairmen — heads of national and regional atomic energy bodies — and a Conference of Atomic Laboratory Directors.

The report was commissioned by the US Joint Congressional Committee on Atomic Energy and, during his fact-finding tour of Europe, Mr. McKinney aroused hostility in some countries by excluding Euratom from background talks he held in Italy (see *Worldview*, June, p 85). However, while critical of US-Euratom developments, *Nuclear Power* understands that the report recommends continued and broadened cooperation with the six-nation Commission, the European Nuclear Energy Agency and the International Atomic Energy Agency.

But it criticizes the US for not co-ordinating research programmes with friendly countries and for being at cross-purposes with Euratom, ENEA and the IAEA. It says US objectives have not really been achieved by the Atoms-for-Peace programme and more use should be made of existing channels for future joint work.

It is to remedy these defects that the new bodies should be formed. The Council of Atomic Chairmen should meet at least once a year to agree on peaceful objectives to provide guidance for joint national and regional research efforts. The other body, the Conference of Atomic Laboratory Directors, should work under this Council and agree on the research programmes to be carried out. It should meet at least twice a year.

Euratom should be included in these two bodies and cooperation between it and the US should be broadened in research matters. This should be in addition to, or in place of, the short-term research activities originally set out under the joint power programme.

A major rôle is assigned to the ENEA. This agency should be considered as a means of implementing the new joint projects agreed upon by the Council of Atomic Chairmen; it could also be used as an alternative to the IAEA in certain respects, notably in assistance to less-developed countries. The US should also become a full member of the Halden boiling water reactor project and also the Dragon project. This would eliminate unwanted duplication by American firms.

Canadian Candu reactor gains W. German interest

Toronto West Germany may build a reactor similar to the Canadian Candu reactor being built at Douglas Point, Dr. Siegfried Balke, West German Minister for Atomic Affairs said here recently. His two-week trip around the Dominion was made to discuss the buying of Canadian uranium, to have talks on waste disposal and to inspect Canadian atomic establishments.

If the Candu reactor, scheduled for completion about 1964, were successful, W. Germany would wish to buy technical information to enable her to build a similar reactor, Dr. Balke said. He was impressed by the way Canada had held to her programme for developing a nuclear reactor fuelled by natural uranium and cooled and moderated by heavy water; it was the only design based on reasonable commercial calculations, he said.

Enrico Fermi decision to go to Supreme Court

Washington Following the turning down by the US Court of Appeals at the end of July for a rehearing on its decision to set aside the construction permit issued to the Power Reactor Development Company, the USAEC has taken steps to seek a review in the Supreme Court. (see *Worldview*, July p 66 and August p 65).

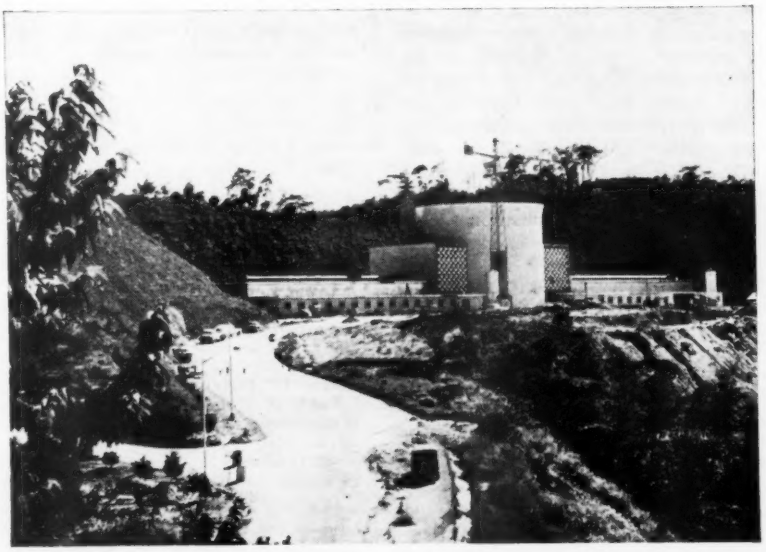
Construction work at the Enrico Fermi plant is continuing and will go on until the appeal has been heard.

AEC's emphasis on beryllium-clad fuel elements

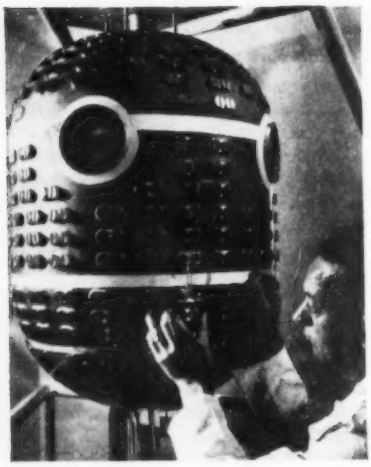
Washington A change in the research and development programme related to the East Central Nuclear Group and Florida West Coast Nuclear Group's gas-cooled prototype nuclear power plant towards the early development of beryllium-clad fuel elements, has been announced by the AEC. It is expected to delay the completion of the plant, originally scheduled for July 1963, by one to two years.

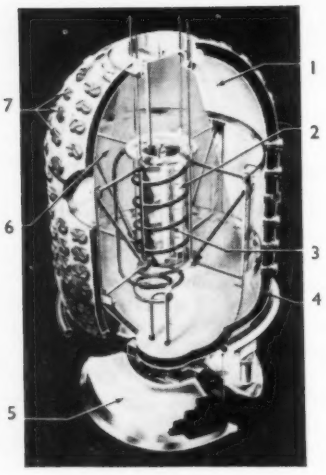
The object of the change is to resolve technical problems involved in using beryllium as a cladding for fuel elements before a decision is made to construct the prototype plant. Previous research emphasized the development of fuel elements clad in stainless steel for the first core loading.

• **Canada** Agreement on increased co-operation in developing heavy water-moderated reactors has been reached with the US.



VENEZUELAN RESEARCH REACTOR Venezuela's first research reactor which recently went critical, is to be formally opened this month. An open pool 3 MW type, it will be used by the Venezuelan Institute for Scientific Research to investigate medical and bio-chemical problems and as a basic research tool





SPACE GENERATOR TESTED Snap-1A, a 125 watt light-weight system designed to provide auxiliary power for space vehicles, is prepared for electrical tests at the Martin Co., Baltimore. Heat from cerium-144 will be converted into power by the thermocouples on the outer skin. The cutaway drawing (right) shows (1) space for liquid mercury shield; (2) cerium-144 pellets; (3) cooling coils used in ground handling; (4) insulation; (5) heat shutter; (6) radiant heat reflector; (7) thermoelectric couples

US small power plant studies

Washington A joint proposal by two American companies to develop and design a compact nuclear power plant having an electrical power rating of 2000 to 3000 kW for military uses is being studied by the US Atomic Energy Commission. The AEC has selected, as a basis for contract negotiations, the proposal by Nuclear Development Corp. of America and General Motors Corp.

The Commission intends to have preliminary design and development efforts on the project go on for a year, after which an evaluation will be made of the results of design and development effort. A decision will then be reached on the reactor system to be selected.

• **United States** Amendments to agreements for cooperation in civil uses of atomic energy have been signed by the US and the governments of 11 countries. The amendments in general are with countries whose agreements were to expire this year and provide mainly for two year extensions.

• **Israel** The 1 MW research reactor near Tel Aviv has started operations. Its power is to be raised to 5 MW in the future.

• **United States** The National Aeronautics & Space Administration has selected the Lockheed Aircraft Corporation and the Martin Co. for six month 'paper' studies on the requirements of a nuclear rocket flight test programme.

Brazil plans new uranium plant

Sao Paulo Another plant which will produce pure uranium, using the process developed by Brazilian scientists recently, is expected to be in operation at the Atomic Energy Institute here within the next month. The new process is said to be cheaper and more simple than the US process. Capacity of the new plant will at first be 250 kilos, which would later be expanded to one ton per month. The Institute has had a small pilot plant in operation for over four months.

Phillips will operate organic-cooled reactor

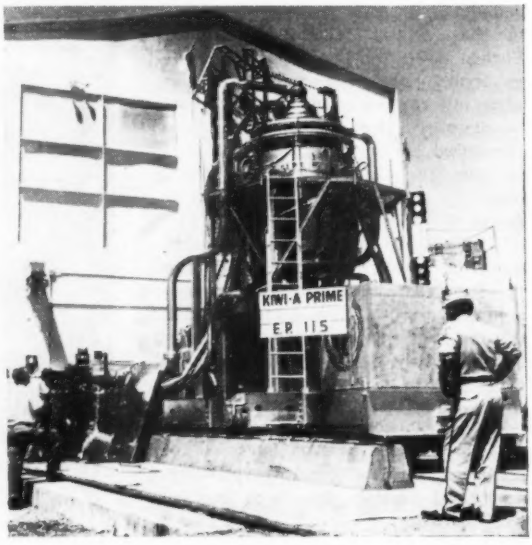
Washington The experimental organic-cooled 20-40 MW reactor to be built at the National Reactor Testing Station, Idaho Falls, Idaho, is to be operated by the Phillips Petroleum Company. According to an AEC announcement, the reactor is scheduled to go critical late in 1962. It will be a flexible facility to be used for experiments aimed at the development by the middle 1960's, of economically competitive reactors which are cooled and moderated by organic liquids.

Rocket reactor tested successfully

Los Alamos A successful full power ground test of Kiwi-A Prime, the second in a series of nuclear reactors used for investigating nuclear rocket propulsion, took place recently at the USAEC's Nevada test site.

The experiment involved a barrel-shaped device, roughly five feet in height and diameter, with a radioactive core of uranium-235. High-pressure hydrogen gas flowing through the reactor system, was heated to thousands of degrees in split seconds and violently discharged into the atmosphere through a nozzle. Instrument readings indicated that the test met all specifications but the reactor, say scientists at Los Alamos Scientific Laboratory, has first to be taken apart and its core examined for damage before any definite conclusions can be reached.

A third reactor system, Kiwi-A3, is scheduled for operation later this September. The first, Kiwi-A, underwent a successful power run in July, 1959. The programme aims at developing a nuclear rocket engine possibly within the next five years.



ROCKET REACTOR A mock-up of Kiwi A-Prime, the nuclear rocket engine under development by the AEC, before its successful test in July. It is the second model to be tested (see story above)

New core for US reactor

Canoga Park, Calif. The 50 MW KEWB research reactor operated by Atomics International for the USAEC, has reached a power peak of 2300 MWt after the installation of a new core vessel. KEWB, for Kinetic Experiment on Water Boilers, is a homogeneous reactor fuelled with a solution of uranium-235 and was designed and built to conduct reactor safety studies. It is operating at Atomics International's field laboratory near Los Angeles. The new core enables the reactor to more than triple its previous pulsed thermal power output of 650 MW.

Argonne Synchrotron will be ready in 1962

Philadelphia Work is expected to be completed this winter on the first sections of the Zero Gradient Proton Synchrotron (ZGS) for the Argonne National Laboratory. This machine will accelerate particles to energies of 12,500 million electron volts.

The building of the ring of eight magnets for the ZGS involves glueing and bolting together 40,000 half-inch tapered steel sheets weighing a total of 5,000 tons. Delivery of the final sections is expected in October 1961 with the ZGS scheduled for completion in 1962.

Improved US Boiling Water Reactor Plan

Washington The USAEC has selected the cities of Los Angeles and Pasadena as operators for a 50 MW Improved Cycle Boiling Water Reactor and the General Electric Co. of California as the reactor supplier. The selection was made under the AEC's Power Demonstration Reactor Programme.

The plant is scheduled for completion in mid-1963 and will be the prototype for a 300 MW reactor incorporating internal steam-water separation and other features aimed at reducing power costs.

US Army buys Triga reactor

San Diego An adaption of General Dynamics' Triga research reactor, making it capable of providing short pulses of intense nuclear energy for the study of radiation effects on electronic equipment, is to be supplied to the US Army.

It will be located at the Walter Reed Army Medical Centre, Maryland, and its primary purpose will be the study of radiation effects on various types of electronic components and circuitry used in Army Ordnance equipment.

Construction will begin later this year with completion scheduled for the latter part of 1961. The reactor and its associated facilities will be known as the Diamond Ordnance Radiation Facility.

NUCLEAR PLANE One version of an atomic-powered aircraft being designed for the US Air Force (see story below)

Convair release nuclear plane design details

Washington A glimpse of the design studies for a nuclear-powered aircraft being conducted by Convair Division of General Dynamics Corporation for the US Air Force was given recently when drawings were released showing two swept-wing planes.

This style is said to be one of several possible configurations under study by Convair. The planes themselves have an assembly of jet-like engines and lack conventional tails; at each wing tip is a vertical stabilizer assembly.

To power these possible planes, two kinds of nuclear engines are being developed: a direct air cycle engine by General Electric Company and an indirect cycle engine by Pratt & Whitney Aircraft. No choice has yet been made of the power plant to be used in the first plane. However, in June, the Assistant Secretary of the US Air Force, Mr. C. Perkins, said an engine for the first US nuclear-powered aircraft would probably be available in about 1965.

In support of the programme, Convair has been conducting an extensive programme of research to investigate the lightest means of shielding the crew against radiation and to measure the effects of radiation on aircraft components. The Division operates two nuclear reactors of its own design, one of which was tested in a modified B-36 bomber.

Shippingport power to be raised

New York An increase in the power capacity of the 60 MW Shippingport pressurized water reactor to more than 150 MW is to be undertaken under a three-year contract signed between the USAEC and Westinghouse Electric Corporation.

The contract extends the operations of the Bettis atomic power laboratory for another three years. It emphasizes continued advancement of nuclear power for naval propulsion and electric power generation. The increase in the Shippingport reactor's capacity will come through the development of a new fuel charge with a designed energy output more than five times that of the first charge used.

Other work includes research, and development on new and improved reactor plants for naval vessels, longer life fuel cores, advanced fuel elements, special materials and components and basic reactor technology. The contract also covers the operation of related facilities at the AEA's National Reactor Testing Station.

• **Canada** Uranium oxide production in the first three months of this year totalled 3,855 tons against 3,881 tons in the same 1959 period.

• **Brazil** The nuclear power station at Mambucaba will take about four years to complete, including over ten months for the study of tenders, says Admiral O. Cunha, president of the National Nuclear Energy Commission.

• **Canada** In the year to March 31, Atomic Energy of Canada obtained 90% of its radioisotopes revenue from overseas sales.

• **United States** The AEC's Gas Cooled Reactor Experiment was operated at 1850 kW for 48 hours on July 22–24.

• **United States** A cesium cell produced 90 watts of electric power directly from nuclear fission, General Dynamics' Atomic Division has announced.

Lloyds' 'charter' for nuclear ships

PROVISIONAL classification rules for the US-Euratom research and develished by Lloyd's Register of Shipping. Specific and detailed requirements are laid down for materials, longitudinal strength of hull, pressure vessels and components, reactor engineering and control and the provision of emergency power. Adequate provision is made for designers to put forward original ideas and the requirements themselves will be subject to continuous review.

Under these rules, welded construction is to be adopted for all structural material bounding the reactor compartment. Special consideration is given to protection in case of shock or collision; reactor components and supports should be designed to stand a shock of 3*g* in any direction; side protection into the deck structure will require special consideration and a double bottom structure not less than 6 ft in depth is to be fitted 'in way' of the reactor compartment. This should incorporate a longitudinal system of framing in association with bottom transverses.

Cargo spaces are to be isolated from the reactor compartment which itself is to be gas-tight and tested on completion to a pressure of 4 lb/in²g. For the containment vessel, the rules say it should be supported and located so that the bottom shell 'in way' of the compartment can sustain comparatively severe local damage without prejudicing the support of the reactor and its relative position.

Other points are as follows:

Pressure Vessels Four categories are given and detailed provision is given for the design and materials to be used.

Pressure Relief Systems These are to be designed to provide total relief capacity during an agreed credible emergency condition with the maximum pressure accumulation of 10% of the design pressure with the additional safety valves isolated. Provision is to be made to detect leakages from safety valves and to isolate them.

Reactor Engineering Safe reactor operation is to be possible with one half of the total heat exchanger capacity out of action; data on the reactor's stability under regular cyclic motions up to accelerations of 0·45 *g* is to be provided and two means of charging coolant in the primary system will be necessary.

Reactor Core Specifications of all materials to be used in the core structure are to be submitted for approval and all reactor pressure vessel internals are to be capable of being dismantled and removed from the pressure vessel.

Fuel Elements Fission products in the fuel are to be assessed at the end of the designed core life, 'assuming a final period of 100 hours full power operation'; corrosion rates of the fuel assembly materials in coolant and in sea water are to be determined.

Reactor Shut-Down The reactor must scram under the following ship conditions:—(1) 50% list; (2) 10 degrees trim and (3) submerging of the centre of containment to 50 ft below water level.

Shielding Crews should not receive an integrated radiation dose in excess of 5 rems per year.

Effluent Disposal Generally, all solid and liquid effluents should be contained for a period of three months' full-power operation. Temporary storage and controlled discharge is acceptable.

Emergency Power Unless two or more reactors capable of independent operation are fitted, an independent power supply with a range of 1000 miles at a speed of six knots, is required.

Maintenance All machinery used directly in conjunction with the reactor shall normally be subject to survey at two-yearly intervals.

US-Euratom Research

A FURTHER step towards implementing the US-Euratom research and development programme was taken recently when 45 proposals for research and development work, amounting to about $M78, were accepted for contract negotiations within the Community and the US. Much of the work authorized involves close collaboration between the 28 Community and ten US organizations represented. The list of contracts is as follows:

COMMUNITY CONTRACTS

Sintering in air of mixed uranium and thorium oxides—*Compagnie Industrielle des Combustibles Atomiques Fritte (CICAF), France*

Improving sintering of uranium oxide by adding oxides of di, tri and/or pentavalent metals with a view to increasing thermal conductivity—*Compagnie Générale de Télégraphie Sans Fil (CFS), France*

Research on uranium oxide extrusion—*Compagnie Industrielle des Combustibles Atomiques Frittes (CICAF), France*

Diffusion of fission gases in reactor materials—*Hahn-Meitner Institut für Kernforschung, Berlin, Germany*

Reprocessing of irradiated fuels using non-aqueous methods—*Centre d'Etudes de L'Energie Nucléaire with the Société Belge de L'Azote et des Produits Chimiques du Marly and Société d'Etudes de Recherche et d'Applications pour l'Industrie (SERAI), Belgium*

Fundamental research on corrosion using electrochemical methods—*Centre Belge d'Etude de la Corrosion, Centre d'Etude de l'Energie Nucléaire and the Société d'Etudes, de Recherches et d'Applications Pour l'Industrie, Belgium*

Fabrication by swaging of oxide, oxide mixture and monocarbide of uranium based fuel elements—*Nuklear-Chemie und Metallurgie, Germany*

Longitudinal deformations of zirconium alloys due to temperature variations; Stability of certain reactor structural materials; Zirconium alloys containing mainly Nb or Si with a view to their utilization as cladding material in water-cooled reactors—*Metallgesellschaft, Germany*

Obtaining of uranium oxide pellets with the addition of beryllium oxide and an alkaline earth or metal oxide—*Battelle Institut, Germany.*

Treatment of radioactive water and waste—*Centre d'Etude de l'Energie Nucléaire (CEN) in conjunction with Evence Coppeé, Belgium*

Fabrication of uranium carbide and mixed carbides and of uranium carbide based cermets—*Nuklear-Chemie und Metallurgie, Germany*

Sintered uranium oxide; sintering behaviour under irradiation—*Commissariat a l'Energie Atomique (CEA), France*

Uranium swelling under irradiation — *Centre d'Etude de l'Energie Nucléaire (CEN), Belgium*

Research on vibrations and pressure losses in tube clusters—*Sogreah, France*

Research programme on heat transfer and kinetics in boiling water reactors—*Techniche Hogeschool, Eindhoven, Netherlands*

Improving heat transfer in boiling water reactors—*Société Nationale d'Etude et de Construction de Moteurs d'Avion (SNECMA), France*

Improving the thermal possibilities of nuclear fuels (Vapotron)—*Compagnie Française Thompson Houston with Alsthom, France, and AEG, Germany*

Preparation of sintering grade UO_2 — *Société Générale Metallurgique de Hoboken, Belgium*

Wet preparation of UO_2 powders — *Comitata Nazionale per le Ricerche Nucleari (CNRN), with Fiat, Italy, Siemens, Germany*

Formation of zirconium hydride in zircaloy 2 and Zr-Nb alloys — *Fiat, with the Comitato Nazionale per le Ricerche Nucleari, Italy*

Reactor physics—*French Atomic Energy Commission*

Preparation and irradiation of uranium—uranium carbide and stoichiometric uranium carbide cermets; Application of transient electro-chemical methods to the chemical analysis of products relating to nuclear chemistry — *Brussels Free University, Belgium*

Flux measurements of fast neutrons by means of new detectors—*Nuclear Energy Study Centre, Belgium*

Sintering of uranium oxide in water steam; Fabrication of uranium oxide fuel elements by swaging; Fission gas diffusion in uranium oxide—*Fiat, Italy, with Westinghouse, USA*

Study of water-steam mixtures as heat transfer liquids and the possibilities of using these mixtures in water-moderated reactors—*Centro Informazioni Studi Esperienze with Ansaldo, Italy, and Nuclear Development of America*

Study of sinterability and industrial sintering of uranium oxide—*Nuclear Metallurgy and Mechanics (MMN), Belgium, with Westinghouse, USA*

Determination of the hot channel factor by the statistical method—*Fiat, Italy, with Westinghouse, USA*

Use of plutonium fuel in nuclear reactors—*Association Belgonucleaire-Cen, Belgium, and APDA, USA*

USA CONTRACTS

Fission gas diffusion in uranium oxide and cladding materials—*Radiation Applications*

Development of new zirconium alloys—*Armour Research Foundation*

Study of limit performances of uranium oxide fuel elements in a reactor—*General Electric Company*

Phase diagram study of the uranium-carbon-oxygen system—*North-Carolina State College*

Development of ceramic fuel element plates obtained by spray-coating—*American Standard Corporation*

Research on heat transfer and bubble coefficient in boiling water reactors; Development of uranium nitride as fuel for reactors using slightly enriched uranium—*Battelle Memorial Institute*

Investigation into the possibility of producing zircaloy-2 tubes by cold extrusion; Experimental study of the effect of ultrasonic vibrations on burnout in boiling water—*American Standard Corporation*

Study on plutonium recycling in light-water-moderated reactors—*General Electric Company*

Determination of the integral of resonance of U-238; Development of UO_2-based fuels—*Babcock and Wilcox with Indatom, France*

This month 'Nuclear Power' looks at valves in atomic energy. Basic types and uses are reviewed in the article below. Following this C. D. Blakeborough examines the design of gas valves, and the problem of corrosion is dealt with by H. E. Threlfall. Industry's participation is shown by the list of suppliers and types on pages 103-8.

Valve types and applications

BEFORE DEALING with the different types of valve and their use in reactor systems it may be worthwhile to take a quick look at some of the engineering problems common to all valves.

Sealing

Valves must be sealed against loss of pressure at at least two points. They also have to be dismantled for maintenance purposes and this is provided for by having a bonnet—a removable part of the body. The stem or spindle also passes through the bonnet, which therefore contains the stem-sealing device, and the bonnet itself must be sealed to the body. Sealing is also required at the joint of the valve with the ducting. On most nuclear applications a gastight seal is made by welding.

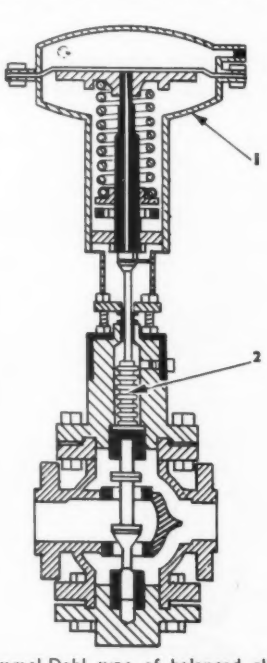
Bonnet sealing The commonest form of sealing is simply to screw the bonnet to the body but a disadvantage is that a turning engagement is then required between them. This can be overcome by using a union bonnet with the joint sealed by a gasket.

This method is used on the smaller sized valves; for larger types, the body and bonnet are flanged and sealed with a gasket. For extremely large valves, the weight of the flanges becomes excessive and other methods such as pressure sealing and lip sealing are used. Because of the need for extreme leaktightness, some manufacturers have designed bonnetless valves.

Stem sealing A stuffing-box containing a flexible packing material such as lubricated asbestos, or Teflon in the form of shreds, square or wedge rings, or chevron rings, is the commonest form of stem sealing. Teflon is normally used as a packing material for valves which undergo severe process use. The packing material must have certain characteristics if it is to serve its function. These may be detailed as: inertness to the fluid to be handled, low friction when packed tightly, resilience so that tightness is maintained inspite of irregularities of the stem, low expansion, and resistance to cold flow. The packing is lubricated so that the stem does not have an excessive resistance to motion and the valve may be easily operated. For low temperature the valve may be fitted with an extension bonnet so that the packing box is in a higher temperature area; for high temperatures the bonnet can be finned to reduce the packing box temperature.

Since stuffing boxes require periodic attention to ensure a perfect seal, packless methods are now popular where corrosive or radioactive materials are being handled. One method is to use a rubber, neoprene, plastic, or Teflon diaphragm between the bonnet and body (see Fig. 2).

Another packless sealing method is the bellows seal (see Fig. 1). This is common in nuclear applications where absolute leaktightness is required, but suffers from the disadvantage of allowing only a small stem movement. These seals are usually backed up by



Hammel-Dahl type of balanced globe valve, diaphragm operated (1); also showing a bellows seal (2) (Fig. 1)

Do you remember?

BASIC TYPES

1. *Control of flow in either direction*
   Stop valves: gate, cocks and plugs, slide valves and blast gates, piston valves, liquid-sealed valves
   Throttling valves: globe, angle, Y, needle, balanced valves, plugs, butterflies, dampers, diaphragm, pinch
2. *Prevention of flow in reverse direction*
   check and stop-check valves
3. *Control of downstream pressure*
   regulating, reducing
4. *Control of upstream pressure*
   safety relief valves
   back-pressure valves

CONTROL

Most valves are intended for manual operation but the size of some used for nuclear applications, their need to be inaccessibly positioned and the radiation hazard factor, makes remote power operation and control more common than in other fields. Valves can be classified simply on the basis of the controlling action; whether by a linear movement of the spindle or stem as in diaphragm, gate, and globe valves or by a rotary movement as in plug and butterfly valves. Basic control mechanisms are as follows:

1. Pushing a disk or plug into or against an orifice either stopping it completely or partially. Used in globe, angle, Y, needle, and balanced valves.
2. Sliding surface moved across an orifice stopping it completely. The surface can be flat, cylindrical or a truncated cone. Used in gate, plug, slide, wedge, piston and sleeve valves.
3. Rotating a disk or ellipse for complete or partial closure. Used in butterfly valves and dampers.
4. Compressing a flexible material which is part of the flow passage for partial or complete closure. Used in diaphragm and pinch valves.

another bellows seal placed either concentrically or above the primary seal, or by a conventional gland seal.

Fabrication

Valve bodies are either cast, forged, or fabricated from steel sheet. Some manufacturers think that castings have too high a porosity for use on gas circuits and so insist on large valves for the main gas ducts in a reactor being fabricated from sheet steel. In small valves, the passages are usually machined in the solid forging or the valves themselves are machined entirely from bar stock. (For a fuller treatment of the question of casting and fabricating valves see Mr. Blakeborough's article, p 96 this issue.)

Materials

The trim of a valve, which includes the stem, plug, disk or other closure, and the seat, if a removable seat is used, is usually of more expensive material than the body. Typical trim materials are stainless steel, stellite, nitrided steel, and Teflon, while the body is made of such materials as cast iron, forged steel, brass, etc. For special applications such as the PWR and BWR and liquid metal cooled reactors, valves are made throughout of stainless steel. It is essential that pairs of materials used for the body and trim should not be too far apart in the electrochemical series to prevent galvanic corrosion; a table giving pairs of materials suitable for body and trim is given in Mr. Threlfall's article on p 100. For special applications, valves can be made in any kind of alloy, either cast or forged, or plastic.

Specific types

Although there are only a few basic types of valve there are a number of modifications of each type. *Gate* valves are used as stop valves as throttling tends to erode the seat and gate. The gate rises clear of the flow passage so that there is a low pressure drop. The main differences in design detail are concerned with the design of the disk or gate, the seats, the stem, and the method of bonnet attachment. The four main types of disk design are the solid wedge, the one-piece flexible disk, the double wedge (see Fig. 2), and the parallel slide valve. Gate valves of the parallel slide type are most commonly used on the gas circuits of nuclear power stations as isolating valves where rapid shut-off is not required. Another special type of gate valve is the rotating gate valve where the gate slides across the passage between parallel body surfaces which are at right angles to the flow direction.

The *globe* type valve has three different types of disk: composition, metal or plug type. The latter is used for throttling as it has a long contact surface; in this it is similar to the needle valve which has a long tapering plug used for fine flow control. The globe valve has a high flow resistance as the flow direction takes two right angled turns; this is overcome in the Y valve where the partition containing the orifice is set at 45° to the direction of flow, thus eliminating one right angled turn. A modification which is commonly used in process work is the flush bottom outlet valve. There are two main variations: in one, the disk rises into the tank to open and in the other, it lowers into the body to open. One consideration when using a globe valve is whether to have the high pressure side above or below the disk; above the disk it aids tight closure.

Balanced valves are essentially a modification of the globe valve with split flow and a double seat. A typical example is the Hammel Dahl valve illustrated in Fig. 1. The idea of using a balanced valve is to reduce the operating effort required, though perfect balance is not obtained as one orifice is slightly larger than the other to allow disassembly.

Plug valves employ either a cylindrical or tapered plug. In tapered plug valves, the lubricant seals the plug and lubricant pressure applied beneath the small end of the plug can be used to unseat the plug in the case of sticking. In non-lubricated plugs, there is a device is usually incorporated which will allow the plug to be unseated slightly before turning.

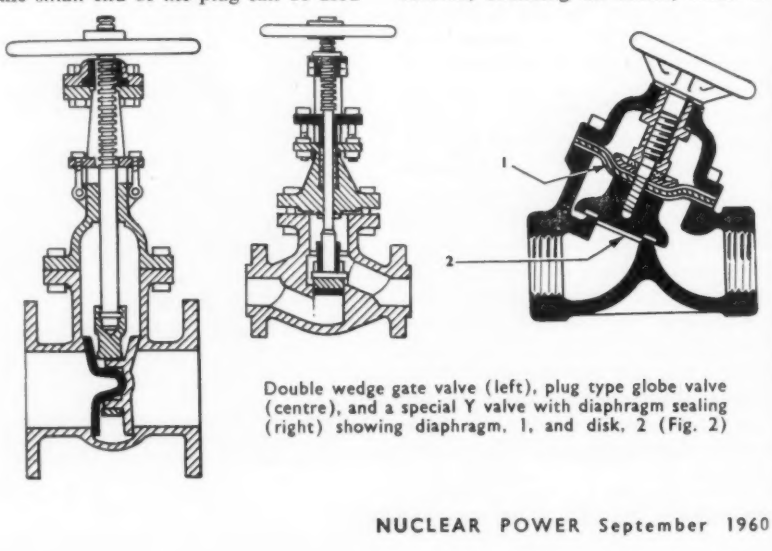
Pinch valves are commonly used for controlling the flow of slurries and consist of flexible rubber or plastic sleeves which are closed by a pinch mechanism. An interesting variation using the iris diaphragm principle twists the sleeve to effect closure.

Valves for gas-cooled reactors

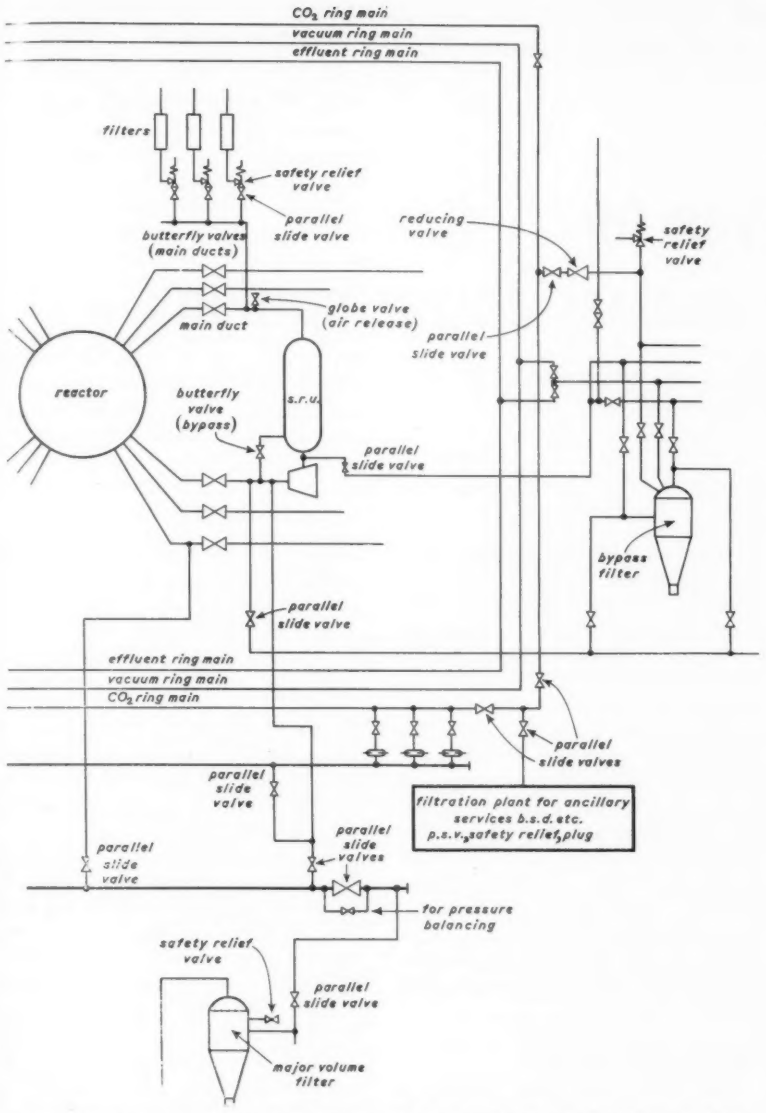
The main problem with the valves used on magnox reactors has been gastightness and the methods of overcoming this are described in Mr. Blakeborough's article. Part of a typical flow circuit is shown in Fig. 3. In the Calder Hall reactors a loss of coolant of about 1 ton/day has been reported. As well as the dangers of radioactivity, this represents quite a severe economic loss running into several thousand pounds per year. On the steam side of these power stations, the conditions are not as stringent as those in fossil fuel fired stations and the valves used here are conventional.

Water-cooled reactors

In heterogeneous water-cooled reactors some leakage is allowable as long as there is some local ventilation. In this case, conventional valves can be modified to provide for leakage collection between an inner and outer gland seal. These valves have conventional packing with either a soft material such as Teflon, or metallic packing rings. Any failure of the primary gland can be detected by noting increased leakage flow; this is most commonly detected by an electrode system, under which electrodes are shorted, sounding an alarm, when a



Double wedge gate valve (left), plug type globe valve (centre), and a special Y valve with diaphragm sealing (right) showing diaphragm, 1, and disk, 2 (Fig. 2)



Gas-cooled reactor circuit flow diagram showing valve types employed; parallel slide types are normally open, globe types shut (Fig. 3)

collecting sump becomes filled with water.

In heavy water reactors the cost of reclamation makes it essential to keep leaks to a minimum and valves are generally bellows sealed. In homogeneous reactors leakage would involve radioactive liquid and cannot be tolerated; all valves in the primary system are therefore of the highest quality double bellows sealed.

For the Shippingport PWR, parallel slide valves have been chosen for isolating the main coolant circuits. They were chosen in preference to wedge-type gates which have several disadvantages for this type of service: with the valve closed hot a subsequent contraction of the body on cooling would squeeze the gate making it impossible to open; and with hydraulically operated valves, leakage of the operant past the valve stem could also seat the valve too tightly. The parallel slide valve has the disadvantage that there is continuous frictional resistance during operation. The bodies of these 18-in. stop valves are cast in type 304 stainless steel and have proved satisfactory. Each loop also contains an 18-in. check valve to prevent backflow in the case of pump failure.

Liquid metal cooled reactors

Tightness is an essential requirement of liquid metal systems and valves are usually bellows sealed, generally with a back up bellows seal which is placed either concentrically or above the primary bellows in the valve bonnet. It is also general practice to have a leak detecting device. The two main types employ either an electrode which is short circuited when contacted by the liquid metal, or a pressure sensing device which can detect any change in a gas filled space between the bellows.

Bellows sealing is normally used on globe valves where the stem movement is small and is restricted to valves up to about 8 in. bore size. Above this size frozen sodium seals are normally used. Lubrication in this case is by a thin film of liquid metal and the temperature must be carefully controlled, too high a temperature causing leakage and too low seizure. It may also be possible to use conventional gland packing seals with their temperature kept much lower than the working fluid.

Leakage across the seat has been found to be a problem with these valves, especially when they operate at high temperature and there is temperature cycling. For valves that remain normally tight shut, there has been the problem of seizing or self-welding, this occurs where there are two metal surfaces in intimate contact at high temperature submerged in liquid sodium or NaK.

SELECT READING LIST

Pottinger, J. F., 'Boiler safety valves,' London Assoc. of Engineers and Shipbuilding Draughtsmen, 3*s*, Feb. 1957, 44pp, tables, diagrams, bibliography.

Hadekel, R., 'Characteristics and design of hydraulic valves for sensitive servo-mechanisms,' British Messier, Gloucester, April 1952, 29pp, diagrams, bibliography.

British Productivity Council, 'Review of productivity in the valve industry,' London, 2*s*, Jan. 1954, 32pp, tables, diagrams.

Pearson, G. H., 'Design of valves and fittings,' London, Pitman, 50*s*, 1953, 43pp, tables, diagrams.

Valve Production team, 'Valves, steel, iron, and non-ferrous: report of a visit to the USA in 1950,' London, Anglo-American Council on Productivity, 3*s* 6*d*, 1951, 64pp.

Bailey, Sir W. H. and Co. Ltd, 'A guide to valve practice,' Manchester, 1957, 64pp.

Munro, A. R., 'Design of stop valves: basic principles and applications,' 10*s*, University of Queensland (c. 1950).

Hill, R. E., 'Avo valve data manual,' 5th edn., 15*s*, London, 1953, 160pp, illustrated.

Beard, C. S. (ed. by F. D. Marton), 'Control valves,' 15*s*, Instrument Publ. Co., Pittsburgh, 222pp, illustrated.

Beard, C. S., and Marton, F. D., 'Regulators and relief valves,' 15*s*, Instrument Publ. Co., Pittsburgh, 200pp, illustrated.

Pippenger, J. J., and Koff, R. M., 'Fluid-power controls,' 70*s*, McGraw-Hill.

Blackburn, J. F., *et al.* (eds), 'Fluid power control,' $17.50, M.I.T., Wiley, New York.

Novel problems that have been surmounted in the design and manufacture of valves for the main gas circuits are described

Gas valves for nuclear power stations

by C. D. BLAKEBOROUGH, B.Sc., Manager, Nuclear Division, J. Blakeborough and Sons Ltd.

ONE OF THE HAZARDS associated with the gas-cooled system has been the leakage of radioactive carbon dioxide into the atmosphere, and, from the inception, precautions have been taken to reduce this to a minimum. Valves are quite naturally regarded as one of the greater potential sources of leakage, as they are normally of cast construction, embody a gland, and then have three flange joints.

A sound casting has always been regarded as completely impervious to gases, but with the large gas losses initially experienced at Calder Hall, and the resultant determination to eliminate all possible weak links in the coolant circuit, the assumption was made that castings, when compared to forgings or rolled plate, were potentially porous. As yet there appears to be no quantitative proof of this, and many metallurgists are of the opinion that the difference is only marginal. Certainly fabrications lend themselves to more rigorous inspection methods, as flaws can be picked up whilst the material is in plate form, leaving only the weld to be examined in the complete valve, whereas with a casting, those parts that are the easiest to inspect, are also the least subject to flaws. To meet this challenge moulding and inspection techniques have greatly improved in recent years and have gone far to improve casting and quality; furthermore the material and composition of the casting is completely in the hands of the founder and can be held to extremely tight limits.

Fabrication or casting?

For many duties the change to fabrication has much to commend it, but in the case of the complex valve body the extra cost involved can become considerable. Furthermore, globe or screw-down stop valves, which must be one of the most common type in general use, are almost impossible to fabricate. And again, in valves of all types the manufacturer is interested in holding his structure rigid in spite of heavy loads and the integral nature of a casting shows up to great advantage.

For the sizes up to 3 in. bore, forgings have for many years been in common use, and this range has now been extended to larger sizes in the case of single special valves. Several firms have developed and now manufacture fabricated valves from 3-in. bore upwards. In general, two methods of construction are used. In the one the valve body is made up from standard dished ends and solid drawn tubes; in the other two forgings are welded together.

For some time, particularly in high pressure steam application, valves have been butt welded into the ductwork, but no attempt had been made to eliminate the body-to-cover joint. Several manufacturers had reduced the casting weight by introducing a pressure seal, but this method was as suspect of leakage as a flange joint. The most usual method for nuclear applications is to fit a gasket—spirally wound asbestos and a stainless steel, corrugated stainless steel, metal 'O' ring or synthetic rubber 'O' ring—followed up by a seal or canopy weld. The gasket makes the joint during the production and site testing of the valves, whilst the seal weld, which is

Valves for Nuclear Power are very similar to those produced for a thousand and one other applications, the basic designs having been known and proved in service over many years under the most searching conditions. However, this new field has brought with it many design, manufacture, and testing features which have not been met before, most of these springing from the fact that the fluid medium is potentially radioactive. Before, leakage from a valve was mainly a matter of economics and annoyance, rather than public health; the plant valued in terms of thousands of pounds, and not millions; the design was an issue between the customer and manufacturer and not the customer, manufacturer, insurers, and several Government bodies; maintenance carried out once a year, and not as now when the valve is inaccessible for the 20 year life of the reactor. This has meant that each aspect of design has been looked at in a new and more searching light. Added to which there are two features associated with the gas-cooled reactor of particular interest to the valve manufacturer—the fluid medium is a dry gas having no lubrication properties; and materials which had previously been in common use at key points, are now classed as incompatible.

done on completion of these, makes a completely hermetic joint during service.

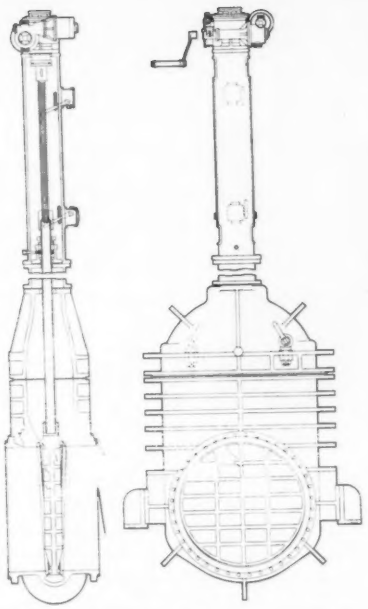
Leakage from the spindle

The leakage most difficult to cure is that associated with the spindle. For steam or liquid, the usual practice is to pack a stuffing box with square section soft packings of graphited asbestos or hemp. The efficiency of this method is enhanced by the fluid itself as, in steam work the lower temperature of the gland causes condensation, filling the pores of the material with water. For temperatures up to 200°C a fluon based packing provides a good seal and is unaffected by radiation. Both valve and packing manufacturers have carried out tests on packings that have been developed specially for hot dry gas service, but at the moment there appears to be no real substitute for asbestos as the basic material. Up to 300°C small leakages are attainable provided attention is paid to the correct bedding in of the packing and surface finish of the spindle. Asbestos alone, however, is not ideal due to its high coefficient of friction which grips the spindle causing high operating forces. Graphite and mica are both added to lubricate the packing, together with a bonding component to hold the constituents together. Above 300°C no real answer seems to have been found particularly when the gland is subject to temperature cycling. The main line of development must be to find a suitable bonding material capable of withstanding high temperatures without decomposition and associated losses in volume. An elaboration of the packed gland is to pipe an external supply of clean fluid to a lantern ring at a higher than line pressure, so reversing the direction of flow. This may be still further developed to be used as the principal means in which make-up fluid is supplied to the system.

It is often requested that the gland leakage should be measured while the valve is under test at the manufacturers. As it is difficult to simulate the exact site temperature conditions at all parts of the valve, misleading results may be obtained. It is better practice to estimate the site temperature of the gland, and simulate this on an independent gland leakage test apparatus.

Bellows sealing

The alternative to a packed gland



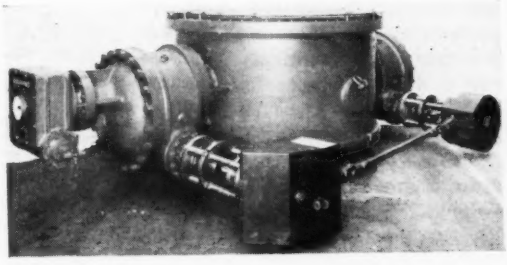
Sections of a 54-in. gate valve, made by J. Blakeborough and Sons Ltd, used on the Calder Hall stations (Fig. 1)

are bellows giving an all metal hermetic seal. Though ideal for some applications there are limits to the pressures that can be withstood and furthermore they are only capable of a movement equal to 10–20% of their free length. As a result a 4-in. parallel slide valve may have an overall spindle height approaching 4 ft 0 in.; it is therefore more usual to find the bellows incorporated in the globe valve which when compared to a gate valve of similar bore has a low lift. The other limiting feature in the use of bellows is the impossibility of transmitting a rotary motion such as is required for butterfly valves. Recent work indicates that this may now be overcome by employing a variant of the crank mechanism. Unfortunately the unit has a limited torque output and may often require a high ratio reduction gearbox between it and the valve spindle.

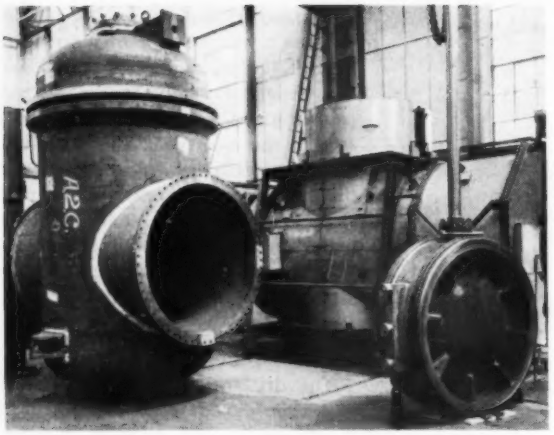
Because of the necessarily slender walls of a bellows they may not form part of the outer pressure vessel and the design normally incorporates a packed gland acting as an emergency seal in the event of bellows failure. The slim walls have also meant that the inspecting authorities have paid them more attention, and both the bellows and valve manufacturers are asked to carry out thorough tests on all units that are put on the market.

Lubrication problems

The dry and non-corrosive nature of carbon dioxide poses a problem of a different nature. Almost of necessity, it is impossible to lubricate those surfaces of a valve which rub together under load such as the faces on a parallel slide valve or the spindle of a globe valve. In steam service the problem is eased by the steam itself acting as a lubricant, but with a dry gas there is a strong possibility that pick up or scuffing will occur, causing possibly seizure, and certainly a rise in the leakage rate. The non-corrosive atmosphere means that no rust is formed on the sliding surfaces, which, even if not a lubricant, at least forms a barrier between the two moving materials. The phenomena of scuffing has long been the subject of research, but although theories abound explaining the mechanics of the event, little guidance is available for those meeting the problem in practice. One generally accepted guide for a choice of mating materials, is that they should both be hard and that one should be harder than the other, but even this has to be qualified to such an extent as to be no longer a rule. In the past Stellite (60% cobalt) had been the most frequently used facing material for high duty steam applications, but because of the long half-life of Co-60 it is looked upon with disfavour, and in some cases expressly forbidden. High nickel alloys are also in common use for bushes and faces



A Hopkinsons Ltd. 66-in. bore 'Tansphere' butterfly valve (Fig. 2)



60-in. parallel faced valve as supplied to Hunterston by Glenfield and Kennedy (Fig. 3)

but nickel forms a low melting point eutectic with the magnox canning material and because loose particles of a high nickel content may be swept onto the cans, it also is suspect. Other materials, although they may give excellent results in the laboratory rubbing tests have not been used in conventional plant and hence no field experience has been gained, which causes designers to think twice before using them. In the face of these problems there now seems to be a relenting on the part of the authorities and it is recognised that the mechanical efficiency of a device is of more value than the theoretical 'nuclear' objections to a material.

Types of isolating valve

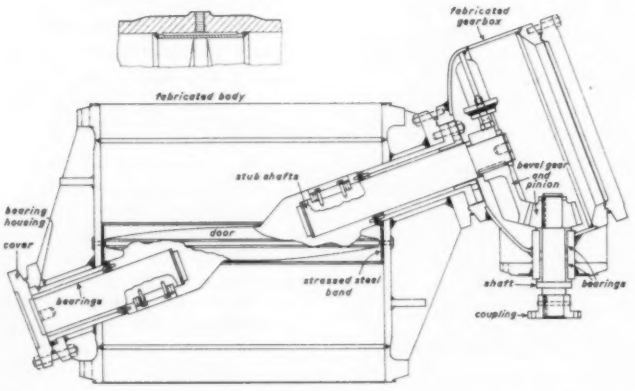
The key valves in any reactor system are those forming a part of the reactor shell, and isolating it from the main heat exchangers. With the gas-cooled system these may be up to 78 in. diameter, and in the later designs have a working pressure of over 250 lb/in² at 400°C. In the stations now complete or in the process of being built both the gate valve (Fig. 1) and the butterfly valve (Fig. 2) have been used for this service.

The design policy for equipment at Calder Hall and Chapelcross was to make as much use as possible of well proved designs. Fifty-four inch valves are unusual in themselves, but at 630°F with a duct pressure of 100 lb/in² they were to be unique. Cast steel wedge gate valves had been made up to 72 in. diameter, and 36 in. diameter valves been in use for forty years at temperatures of over 400°C. It was therefore decided that the wedge gate should be the valve to be used as being the one on which most field experience had been gained. The earlier valves had the body cast in two halves to aid the steel founders, these were then welded together, annealed, and machined. This method led to difficulties in making the joint between the body and cover and subsequent bodies were successfully cast in a single mould. To save space and yet leave the main spindle accessible for lubrication and maintenance a tubular telescopic construction was used; to reduce the operating forces, the body had machined channel guides; valves were equipped for remote operation, with the electrical drive being through a torque limiting, spring-loaded clutch which had given satisfactory and reliable service for many years. Although castings were acceptable, and have since proved quite adequate in service, it was thought advisable to fabricate one of the Chapelcross valves, and gain experience which could be useful in subsequent projects. To keep all the valves interchangeable, an elliptical body was used which, although heavily ribbed, tended to flex when under load. This distortion tended to loosen the body rings causing leakage; modifications, although reducing this, never brought the leakage to the low figures which had been achieved on the cast structure.

Fabricated gate valves of an improved design (Glenfield and Kennedy Ltd.) are being installed at Hunterston (Fig. 3). The sliding action of the door tongue in the channel guides has here been replaced by rollers running on hardened steel tracks; the wedge gate is superseded by parallel faced disks which, after rolling to the shut position, are forced outwards against their seats by the inflation of a bellows unit centrally situated between the two disks; the valves have a cylindrical body giving the necessary strength without the use of many ribs.

Quite apart from its size, one of the disadvantages of the gate valve is the time it takes to close, the standard speed being between 1 and 2 ft/min. In an emergency this is not considered fast enough and from the outset it had always been the aim to use a butterfly valve with its swifter closure and smaller bulk. Butterfly valves have for many years been used in water service but their use was limited to installations not requiring a tight seal. Twenty years ago leak tightness was achieved in the water industry by the introduction of a flexible rubber seat, but for the higher temperatures little success had attended the considerable amount of development work that had been done.

The aim was always to rotate the door, whilst at the same time keeping



Section through a 60-in. 'stress-seal' butterfly valve made by J. Blakeborough and Sons Ltd for Berkeley, the inset shows details of the seal band (Fig. 4)

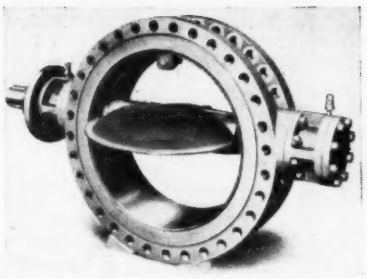
it from contact with the body seat, and then by some simple means bring the door and seat together to form a seal. It has also to be taken into account that the door is of massive construction, designed to withstand heavy loads (a 5 ft 0 in. door when under 150 lb/in² pressure is subjected to a load of 190 tons). Furthermore the door is completely within the gas stream, and as the only heat loss is through the shafts its temperature approaches that of the gas. In contrast, the body, being of similar construction to the ductwork, is somewhat flexible, and, by virtue of the large cooling surface, is at a considerably lower temperature than the door. The seal has therefore to be flexible enough to accommodate both the distortion of the body, and the temperature differentials between the body and door. The latter, although they may be small, are associated with large linear dimensions, so have considerable effect.

There are two valves which have been used in all the Calder Hall type stations now under construction in this country, Italy and Japan. In the 'Stress-Seal' design, the door is rotated through approximately 90° to align with a metal sealing band welded to the body (Fig. 4). A suitable clearance exists at this stage between the door edge and sealing band to allow for relative expansion. Final shut-off is obtained by admitting pressure to the chamber behind the seal band, with the result that the band is deflected to make contact with the door edge. This contact extends round the full periphery of the door, the shaft bearings being clear of the seal as a result of angling the shaft. In the 'Tansphere' valve (Hopkinsons Ltd.) the door is rotated to a closed position, and then, by phased rotational movement of eccentrics, moved axially into the flexible seat (Fig. 2). Again the seal is on the complete periphery, as the shaft is set back from the sealing face. Yet another butterfly design — the 'Cone-Seal' (Fig. 5) — is being developed by J. Blakeborough and Sons Ltd. for the AGR. Here the basic principle has been to keep the valve as simple as possible with the fewest possible working parts. The valves—24-in. bore, 300 lb/in², 1068°F—are situated inside the four heat exchangers at the end of the co-axial ducts. The seal is formed by the door, mounted on an off centre shaft, turning through 90° and in the last 1° of travel wedging into a conical liner. The liner is designed both to be flexible and to remain at the same temperature as the door.

Each isolating valve has to be tested at the working conditions to ensure that it meets the specification. Because of the large loads involved, the test blanks and ancillary equipment become quite expensive, and may, in fact, be equal in value to a complete valve. Each ducting system is a different size but even when the same size there is no standardization of flanges and so a separate set of test apparatus has to be provided for each order. The bodies and doors are hydraulically tested to twice the working pressure; the door because of its awkward shape has often to be tested in a special rig of similar construction to the body. The leakage past the seat is measured both whilst cold and at the working temperature. For the two larger types of valve at the pressures and temperatures concerned the leakage is amazingly small; it has been known to be unmeasurable and rarely rise above 1 lb of gas per day. At the same time it is admitted that the test is conducted under ideal conditions, and it is not to be supposed that the leakage will not increase whilst the valve is in service.

Clean conditions

The specification for reactor valves lays down that they should be supplied to site in 'a clean condition' and to achieve this special workshops have had to be built in which all personnel are dressed in white, clean overalls, and all incoming air filtered. It is in this connexion that one experiences one of those clashes of requirements common in practical engineering. To satisfy the clean condition needs the assembly should be stripped down after all the tests have been done, each component cleaned, moved into the 'clean area', reassembled, and despatched. This, however, is quite unacceptable to the engineering insurers who, quite naturally, wish to see the product tested as the final operation before despatch. A compromise has been reached but again reliability has to take pride of place. Each component is cleaned by shot blasting or degreasing before assembly, and the valve tested. After test the valve is wire brushed with special attention being paid to those



A 24-in. 'Cone-seal' butterfly valve developed for the AGR (Fig. 5)

areas in contact with the gas stream. Loose dust is removed with a vacuum cleaner, and the unit moved into the clean area where more thorough cleaning is done. After inspection, all internal surfaces are coated with protectant, end plates and seals fitted to prevent the ingress of moisture and dust during transportation and storage at site, and dessicant inserted to absorb any trapped moisture.

Large valves have been chosen as the example of most interest. The same design and production problems exist for the smaller sizes although the test procedure is often relaxed, and only a prototype subjected to hot test. Because of this, the valves can be fitted, tested and packed for despatch all within the clean area.

Valves for other reactor types

Most experience has been gained in this country with the gas-cooled reactor, but with the rising interest in the ship propulsion units employing the PWR or OMR systems, designs are now being produced for this service. Both types have the advantage of not being dry, and the valves will be very similar to those now being made for high pressure feed water service, with, of course, special attention being paid to the prevention of leakage into the atmosphere.

Of course valves in the gas ducts are not the only ones required for the complete station. The conventional equipment still requires steam, feedwater and cooling water valves but these follow the same pattern as those in the thermal power stations; in fact in the case of steam valves the temperatures and pressures are below those in modern conventional plant so the valve designer has something in hand awaiting further developments in engineering and metallurgical aspects of nuclear power generation.

Compatibility of materials, crevice corrosion and galvanic corrosion all pose problems for the design engineers

Corrosion-resisting valves

by H. E. THRELFALL, B.Sc. (Eng.), Sales Manager, Langley Alloys Ltd

THE TERM 'corrosion-resisting' is normally taken to mean valves employed for handling corrosive chemical products or intermediates rather than for water, steam and similar duties. Further, with the more widespread use of stainless steel and special alloy valves the term is sometimes applied to these valves to the exclusion of valves in iron, steel or bronzes, which should, of course, be included.

Construction materials

The material of construction is the pivot point of the valve application since it will be dictated or restricted by the corrosive to be handled and will in turn impose limitations on valve design and, possibly, operation Materials commonly available are:

(1) Cast iron
(2) Cast steel
(3) Lead and alloys of lead
(4) Bronzes
(5) Stainless steels
(6) Special alloys

Cast iron is very widely employed for handling waters of all kinds, caustic solutions and concentrated sulphuric acid. Special irons also are used for improved life on caustic liquors and silicon irons (containing 14% Si) are used for a wide range of sulphuric acid concentrations and temperatures. Lead and lead/antimony valves are also frequently used with sulphuric acid and possess the particular features of ease of repair and relatively good scrap value. The uses of cast steel are generally limited to more mildly corrosive conditions but where mixtures with petroleum oils are involved the inhibiting effect of the hydrocarbons on the attack by the corrosive may often be most marked and will allow the use of this relatively inexpensive material.

Bronzes are employed on many duties for corrosive waters, acids and alkalis and frequently offer outstanding service on sulphuric acid duties. The alloys used are usually true bronzes of copper and tin (sometimes referred to in this context as acid-resisting bronze) or aluminium bronzes, but it must be emphasized that many so-called 'bronze' valves are in fact made of gunmetals and the corrosion resistance of such valves may be disappointing because of the selective corrosion attack on the zinc content of the alloy.

Stainless steels are, of course, now widely used and will handle very many salt, caustic and acid solutions. The most notable application of the standard 18% Cr–8% Ni type of stainless steel is with nitric acid. An addition of about 3% molybdenum to such an alloy modifies the corrosion resistance, for example, by improving resistance to pitting on alkaline duties and increasing to some extent the very limited resistance of the simpler alloy to sulphuric acid. It should however be stressed that the addition of molybdenum does not necessarily make the alloy 'better' (in fact with some nitric acid conditions, for example, it could be worse) but merely different.

On many duties the particular feature of stainless steel will be not merely the life of the valve but also the relatively low possibility of contamination of the fluid handled by corrosion products. Where this is desirable the use of iron or steel may be ruled out although the actual valve life may be quite satisfactorily economic.

Special alloys

Of the special alloys which can be used in valve manufacture most of these at the present time tend to be either higher alloys of the stainless steel type (that is to say they will contain probably more than 18% Cr, 8% Ni, and 3% Mo but will still have a substantial iron content) or nickel base alloys. Of the high alloy stainless steels, the alloy known widely in the USA as '20 Alloy' is now finding increasing application on this side of the Atlantic. The nominal composition is 29% Ni, 20% Cr, 4% Mo, 4% Cu, balance iron with controlled carbon contents. Trade names for alloys of this type include Durimet 20, Langalloy 20V, and Aloyco 20 and they all possess excellent resistance to sulphuric acid over a wide range of conditions. On many other duties such as phosphoric acid and acetic acid they offer improved corrosion resistance as compared with the standard 18/8/3% Mo types of stainless steel. Coupled with this is the fact that finished valves in 20 alloy are only about 15% more expensive than valves in the standard type of alloy.

As a result valves and pumps as

critical components in the system are quite frequently made of this alloy although the vessels and piping may be of the standard 18/8/3% Mo type of alloy.

Perhaps the most well-known nickel alloy is Monel which contains approximately 70% Ni and 30% Cu. It has excellent resistance to many waters, salt solutions and caustic liquors as well as to many milder acid solutions. Other nickel alloys include alloys containing molybdenum, chromium and perhaps a few percent of copper and these are generally characterized by good resistance to sulphuric acid and almost all salt and caustic solutions. Some are also resistant to oxidizing conditions and to nitric acid (usually those with 15% or more of chromium) and one type which is basically an alloy of nickel and 30% of molybdenum is highly resistant to many hydrochloric acid conditions for which most other metals and alloys are usually unsuitable. Pure nickel also is sometimes employed, usually for considerations of purity and freedom of contamination of the fluid.

Plastics and rare metals

Mention should also be made of metals such as tantalum and titanium which are sometimes used for valves for specific conditions but up to the present the high cost of such metals and the difficulties of valve manufacture have made the finished valves very costly and not of very likely general use. Plastics of many varieties also are now extensively used for valves but must be considered separately due to entirely different mechanical and physical properties and methods of manufacture. The use of plastics for items such as gland packings and gaskets however should be considered and one of the most used of these is polytetrafluoroethylene sold usually under the registered trade names of Fluon or Teflon. In recent years the use of this material either alone or with asbestos has increased enormously and has solved many problems. Where it is used alone as a gland packing the surface finish of the valve stem is particularly important for best results, as is a fairly close tolerance on stuffing box diameter.

This material, p.t.f.e., is also now often employed as one half of a valve sealing element, either as the disk or seat facing, since it is inert to almost all conditions and will flow to take up irregularities due to wear or corrosion in the mating part. However it must be restrained in some measure because its tendency to flow must be limited in order to avoid the need for constant re-tightening.

TABLE 1 *Features of various types of valves*

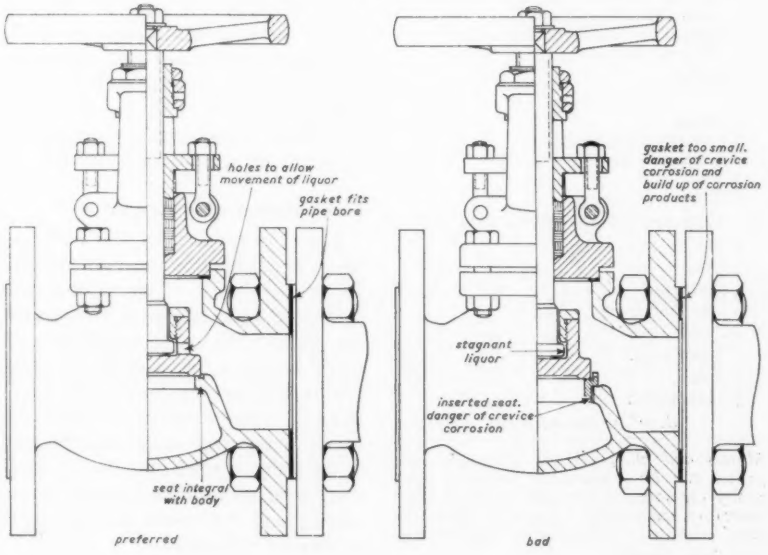
VALVE TYPE	FEATURES AND ADVANTAGES	DISADVANTAGES
GROUP 1 RING-SEALING VALVES		
Globe	Regulating characteristics. Well known principle for ease of maintenance.	Turbulent flow. Resistance to flow.
Y-Type	Screw-down seating arrangement. Fairly low resistance to flow.	Remote manual control difficult.
Gate	Sliding action in closing cleans seats. Pressure tends to hold valve closed tight.	More difficult maintenance.
GROUP 2 AREA-SEALING VALVES		
Plug	Quick open/close. Large tolerance for corrosion before leakage.	Sticking, wear, consequent leakage.
Lubricated Plug	Quick open/close. Large tolerance for corrosion before leakage.	Contamination from lubricant. Need for regular attention.
Sleeved Plug (Sleeve p.t.f.e. or other)	Quick open/close. Large tolerance for corrosion before leakage. ' Self-lubricating '.	Temperature and pressure limits on sleeve.
GROUP 3 LINE-SEALING VALVES		
Diaphragm	Simplicity. Limited use of corrosion resisting alloy needed.	Temperature and pressure limits on diaphragm. Fatigue of diaphragm.
' Pinch ' Type	Extreme simplicity. Usually no metal parts in contact with corrosive. Good for slurries.	Temperature and pressure limits on sleeve. Fatigue of sleeve.

Typical valve designs

All the normally well-known designs are used for corrosion services and the service life obtained must necessarily depend on the specific service conditions and the material of construction. There are, however, a number of general features of each type of valve and these are given in Table 1 for ease of reference. The typical valves referred to are arranged in three groups roughly according to the method of sealing of the valves. This is not a strictly definable method of grouping but serves some purpose in helping to compare the broader classifications first, and then the individual types within the groups.

Reference should be made to the ' pinch ' valve since although it might not be expected to form a part of this survey it is widely used especially for corrosive slurries at normal tem-

Examples of preferred and bad design of valves for corrosive duty (Fig. 1)


holes to allow movement of liquor
gasket fits pipe bore
seat integral with body
preferred
gasket too small, danger of crevice corrosion and build up of corrosion products
stagnant liquor
inserted seat, danger of crevice corrosion
bad

peratures and because of its relatively low cost should not be overlooked.

Effect of material on design

Most bronzes, cast steel, and stainless steels have average mechanical properties and do not therefore impose serious limits on general mechanical design. Cast iron is known to have lower elongation and therefore this must be allowed for. Silicon iron is usually especially brittle and shocks of any kind must be avoided. Lead is on the other hand, ductile and liable to 'creep' at not very high temperatures especially where there are temperature change cycles.

Some of the special alloys, Monel for example, again have average mechanical properties but others may be brittle, hard, tough or otherwise difficult to handle in manufacture, installation or maintenance.

A problem feature of stainless steels and many other alloys is their bad running properties when in contact with the same or similar materials. This can cause premature leakage of the valve due to resultant 'pick-up' between the metal sealing faces. Very careful attention to design of the sealing elements is necessary to overcome this since it is rarely possible to choose two dissimilar metals for their good bearing properties on each other by reason of the corrosive conditions. This is one of the reasons for the use of a non-metal for one of the sealing elements as already mentioned above in the case of p.t.f.e. for such a duty. There are many cases of high temperature, however, where such a solution is not possible.

TABLE 2 *Relative electrolytic potentials of some materials*

'Noble' or protected end

- Platinum, Gold, Graphite
- Silver
- Austenitic stainless steels, Langalloy 20V—Carpenter 20, etc., Langalloy 7R—Illium G, Langalloy 5R—Hastelloy alloy C, Chromium-Iron
- Inconel, Nickel
- Monel, Copper-Nickel Alloys, Hidurax 1, Bronzes, Copper
- Langalloy 4R—Hastelloy alloy B
- Tin, Lead
- Cast Iron, Steel and Iron
- Cadmium, Aluminium
- Zinc, Magnesium

'Base' or corroded end

Metals and alloys shown bracketed together can be grouped as being of virtually the same electrolytic potential and therefore can usually be used in conjunction, without the danger of electrolytic corrosion arising.

TABLE 3 *Safe combinations of alloy materials in valve assemblies*

MAIN BODY MATERIAL	SAFE ALLOY FOR DIFFERENT 'TRIMS' (SEAT, DISK OR STEM)
Austenitic Stainless Steel of 18/8 Type	Langalloy 20V, Langalloy 5R, Langalloy 7R
Langalloy 20V	Langalloy 5R, Langalloy 7R
Monel	Langalloy 4R
Langalloy 4R	Langalloy 6R (Nickel/Silicon)

In most cases a separate different 'trim' material will be chosen allowing the choice of a less costly alloy for the main body parts. In the case of the Langalloy 4R/6R combination, the choice is to permit the use of Langalloy 6R in those special cases where necesary for its particular resistance to corrosion without the difficulties of making the whole valve in this rather hard, difficult-to-handle alloy.

Crevice corrosion

Many of these materials, especially the stainless steels and other alloys containing chromium have a particular feature of susceptibility to 'crevice corrosion'. The phenomenon is displayed in a crack, pit or crevice when the material is in contact with a corrosive to which it is generally highly resistant. Extremely high rates of corrosion may be experienced in the crevice area only whilst the rest of the material is virtually unaffected. For this reason separate or renewable seats in valves made of stainless steel and most other alloys are not recommended as good general practice. Rapid crevice corrosion can cause leakage between seat and body and in many cases the seat becomes completely detached from the body and the body is too severely corroded for repair to be possible (see Fig. 1).

Combination of materials

For economy reasons it is often desired to use a more resistant material for the valve trim (seat, disk and stem) and a less expensive material for the main body parts where there is more tolerance for corrosion before failure. This is frequently possible and in fact is very commonly done in cast iron or cast steel valves. In the case of the stainless steels and special alloys there tend to be more pitfalls for the unwary and it is useful to refer to the two major difficulties.

The one is crevice corrosion already mentioned. It is desirable to determine if this may be a factor if the separate seating is employed. The other is the possibility of electrolytic (or galvanic) corrosion taking place between the two materials used. For this to occur the liquid handled must be an electrolyte. Usually dilute solutions of salts or acids are stronger electrolytes than concentrated solutions. If such liquids are handled the two materials of the construction of the valve must have almost the some potential in the electrochemical table (see Tables 2 and 3). Where the two materials both offer reasonable resistance to similar kinds of conditions e.g. strongly oxidizing or strongly reducing, this is often the case but it is by no means certain, so that investigation is advisable to avoid what can sometimes be a most accelerated failure.

There is a third problem which sometimes arises in the use of trimmed valves and which also is not infrequently encountered when the pipes and valves are of different metallic materials. This is due to corrosion attack on one material by the corrosion products from the other, when these products are soluble in the liquid being handled. It is not possible to lay down any simple rules for avoiding this problem and the only suggestion is to consider the various materials in the system, the likely corrosion products resulting, and their possible effects on any part. When such corrosion does occur it may be confused with electrolytic corrosion because of the preferential nature of the attack. However, a study of the relative electrolytic potentials of the corroded and unaffected parts will help in establishing the true position. If a small area of more noble material is attacked then it is not the result of electrolytic corrosion.

Valves in atomic energy—types and manufacturers

Who makes valves for atomic energy? In many cases manufacturers are not told the final destinations of their products, so that the list below should not be regarded as definitive. It represents, however, the most complete survey yet made of UK valve companies' participation in the new technology

MANUFACTURER	DESCRIPTION AND TYPE	CONTROL	SIZE	MATERIALS	OPERATING PRESS. AND TEMP.	APPLICATIONS	REMARKS
Alexander Controls Ltd.	'Alcon' control valves, globe, diaphragm or disc	Directly operated solenoid or air operated in the case of high temperature and pressure application	$\frac{1}{10}$–8 in.	Stainless steel	Up to 2000 lb/in² and 450°C	For use with argon, helium, nitrogen, air, heavy water, radioactive water, and corrosive acids	Supplied directly and indirectly to the UKAEA
Appleby and Ireland Ltd.	Bellows sealed midget and straight-way gate valves Flanged gate valves, needle valves, globe valves, plug-cocks, quick opening valves	Manual, pneumatic or electric operation	30 mm	Stainless steel, seats of Teflon for temps. up to 250°C	Up to 580°C	For liquid metal service and isotope separation plants	In general use in French nuclear energy plants and used by the UKAEA at Winfrith, Dounreay, Capenhurst, Windscale and Harwell
Appleton and Howard Ltd.	Flush bottom outlet valve		1½–10 in.	Cast iron, cast steel, range of alloys	Up to 250 lb/in²g	For use on acid lines	Supplied to UKAEA, Risley
Sir W. H. Bailey and Co. Ltd.	Reducing valves Back pressure valves Check, butterfly valves Float valves Sluice valves Globe valves Reflux valves Renewable disk valves Safety valves Parallel slide valves	Manually or electrically operated	Up to 6 in. 2 in., 8 in. (max.) 6 in., 12 in. 6 in. All sizes up to 54 in. Largest supplied 6 in. For Chapelcross up to 48 in., others up to 12 in. Up to 3 in. Up to 6 in. From 6 in. up to 12 in.	Cast iron, carbon steel, bronze		Supplied for ancillary services such as cooling water, fire mains, etc.	Supplied to Bradwell, Berkeley, Calder Hall, Chapelcross, Hinkley Point, Capenhurst, Dounreay, Harwell, Sellafield, Springfields, Trawsfynydd, Aldermaston
Bailey Meters and Controls Ltd.	Single and double seated valves, with both fluted plug and ported cage trim	Diaphragm or pneumatic piston actuators according to valve size and stem thrust required	1–5 in. 6–9 in.	Bodies from carbon steel or alloy steels Trims, stainless steel (with hard facing if necessary)	2500 lb/in², 450°F	Water control valves to heat exchangers	Hinkley Point
W. N. Baines and Co. Ltd.	Ground plug type gland cocks Sleeve packed cocks Air suction valves		1 in., 2 in. ½ in. 1¼ in² bore	18/8 stainless steel 18/8 stainless steel 18/8 stainless steel		Used on research reactors	Supplied to UKAEA Supplied to UKAEA Supplied to AEI-JT reactors
Baldwin Instrument Co. Ltd.	Directional control valves (spool type construction) Electromagnetic pilot valves		¼–1 in. $\frac{1}{16}$–$\frac{3}{16}$ in.	Valving spool of mild steel hard chrome plated Body: bronze or brass Magnetic circuit of mild steel	Up to 150 lb/in² air Up to 250 lb/in²		Supplied to UKAEA
Black Automatic Controls Ltd.	Pressure switches Flow switches Solenoid operated valves		¼–1 in.	Stainless steel	up to 10,000 lb/in² (pressure switch) normal temps.	Gas flow, coolant supply, b.s.d. systems	Supplied to Harwell, Risley and Dounreay
J. Blakeborough and Sons Ltd.	Gate type isolating valves, wedge seating	Power operated	54 in. bore	Available in cast or fabricated steel with appropriate trim	125 lb/in²g, 700°F	Reactor main gas valves	Supplied to Calder Hall and Chapelcross
	'Stress-seal' butterfly type isolating valves	Power operated	60 in. 66 in.	,,	60 in: 230 lb/in²g 785°F 66 in: 230 lb/in²g 797°F	Reactor main gas valves	60 in. supplied to AEI-JT for Berkeley, 66 in. being supplied to GEC for Tokai Mura
	'Cone-seal' butterfly type isolating valves	Power operated	24 in.	,,	300 lb/in²g, 1067°F	Reactor main gas valves	On order by UKAEA for Windscale AGR
	Butterfly type throttle valves		66 in. 42 in.	,,	264 lb/in²g, 572°F	Reactor main gas valves for regulating duty, not designed for complete shut-off	On order by APC for Trawsfynydd, 66 in. for main ducts, 42 in. for bypass duty

MANUFACTURER	DESCRIPTION AND TYPE	CONTROL	SIZE	MATERIALS	OPERATING PRESS. AND TEMP.	APPLICATIONS	REMARKS
J. Blakeborough and Sons Ltd. (Cont.)	Globe pattern screw-down valves, with bellows type stem seal		½–1½ in.	Forged steel	137 lb/in²g, 100°F	Subsidiary CO_2 circuits where risk of gland leakage cannot be tolerated	Supplied to AEI-JT for Berkeley
	Globe pattern screwdown valves with gland seal		½–1½ in.	Forged steel	205 lb/in²g, 600°F	Subsidiary CO_2 circuits	Supplied to English Electric for Hinkley Point
	Three-way valves, gland seal		all sizes	Up to 1½ in. in forged steel; larger sizes cast steel	250 lb/in²g, 572°F	Subsidiary CO_2 circuits	Supplied to NPPC for Latina
	Parallel slide valves with bellows type stem seal		3 in. 4 in.	Cast or fabricated steel	137 lb/in²g, 410°F	Subsidiary CO_2 circuits	Supplied to AEI-JT for Berkeley
	Parallel slide valves with gland seal	Manual and power operation	All regular sizes		12 in. and 15 in. 205 lb/in²g, 600°F; 3 in. 137 lb/in²g, 100°F	Subsidiary CO_2 circuits	12 and 15 in. supplied to English Electric for Hinkley Point, 3 in. supplied to AEI-JT for Berkeley
	Parallel slide valves, quick action, rack and pinion type; radiation finned stuffing box		3 in.		205 lb/in²g, 700°F	Subsidiary CO_2 circuits	Supplied to Hinkley Point
	Check valves		½–1½ in.	Forged steel		CO_2 service	Supplied with or without screwdown gear
	Automatic isolating valves		2–12 in.	Cast steel		CO_2 service	"
	Intake screens (power driven, self cleaning) Band type and rotary types of the disc, cup and drum patterns						
	Penstocks	Manual and power operation	All sizes			Circulating water systems, water intakes, screen chambers etc.	7 ft 6 in. × 9 ft 6 in., 8 ft × 8 ft, 5 ft × 7 ft supplied to Sir R. MacAlpine and Sons for Bradwell, 6 ft × 9 ft, 4 ft × 13 ft, 5 ft × 8 ft for Balfour Beattie and Co. Ltd. for Berkeley
	Sluice valves	Manual and power operation	All sizes			C.W. mains, pumping plant, condenser connexions etc.	21, 24, 39, and 54 in. supplied to NPPC for Bradwell, 16, 27, 60, and 72 in. for AEI-JT for Berkeley
	Reflux valves, Blakeborough 'free-acting' type single and multiple door					C.W. pump discharge	54 in. for NPPC for Bradwell, 16, 27 and 60 in. for AEI-JT for Berkeley
	Butterfly valves, metal or rubber seated	Manual or power operation	All sizes			Water service, condenser connexions etc.	30 in. for NPPC for Bradwell
	For L.P. steam, condensate, and feed water a range of types has been supplied to all nuclear power plants and process plants either built or under construction in this country. They include: Sluice valves and reflux valves in small and medium sizes; parallel slide valves for steam and feed water, in cast iron, cast steel, forged steel, and bronze; non-return valves for similar services, in the same range of materials; screwdown stop valves; bronze straightway valves; relief valves; float controlled valves; pipeline strainers; etc.						*A range of Hammel-Dahl diaphragm operated valves for automatic process control has been supplied to the UKAEA installations at Dounreay and Springfields and for the CO_2 storage plant at Bradwell. Self-acting pressure regulators, including reducing and back-pressure versions have been supplied to the UKAEA for process applications.*
Boving and Co. Ltd.	Butterfly valves	Motorized	4–216 in.	Stainless steel	Up to 600 ft head	Condenser C.W. circuits	36 in. motorized valves supplied to AGR and 72 and 42 in. valves for Trawsfynydd
British Arca Regulators Ltd.	Double beat or balanced single seat type	Diaphragm	1½–4 in.	Bodies: cast steel Seats: stellite faced steel	Up to 1400 lb/in²g at 950°F	Pressure reducing and desuperheating, pressure testing	Supplied to Hinkley Point, Berkeley, and Bradwell
British Ermeto Corporation Ltd.	Stop valves and non-return valves	Manual	up to 2 in.	Stainless steel	Up to 1035 lb/in² at 650°F and 2000 lb/in² at 100°F	Hydraulic circuits	Standard UKAEA stores items. Special stop valves for b.s.d. lines supplied to GEC-Simon Carves for Hunterston
Burnett and Lewis	3 or 4 port bellows sealed valves	Electro-pneumatic or electric	1½–6 in.	Body: low carbon steel Bonnet: forged steel Internals: nitrided steel and SG iron Bellows: stainless steel	400 lb/in²g at 300°C	For circuits handling air or other non-corrosive gases for diversion purposes only	Used on the special gas driers supplied for the AGR
CAV Ltd.	Rotary selector valves					For b.s.d. circuits.	
Cockburns Ltd.	Spring-loaded safety valves, changeover valves, bellows sealed stop valves				300°F.	Heat exchanger and reactor safety valves	Supplied for the AGR, Windscale
Crosby Valve and Engineering Co. Ltd.	Safety relief valves		1–8 in. (inlet)	Carbon steel bonnet, body and cap. Stainless steel trim. Special materials all stainless steel, all bronze, all monel	Up to 10,000 lb/in² and 1500°F according to size, application, press./temp. combination	Protection of PV's particularly on ore processing plant	Supplied to UKAEA, Springfields

				bronze, all monel	combination		
Crosby Valve and Engineering Co. Ltd. (Cont.)	Masoneilans control valves, globe and angle	Diaphragm	$\frac{1}{10}$–16 in.	Carbon steel bonnet, body and blind head. Stainless steel trim. Special materials all stainless steel, all bronze, all monel	Up to 3500 lb/in² and 1500°F according to size, application, press./temp. combination	Automatic throttling or on/off control, used particularly on ore processing applications	
De Havilland Engine Co. Ltd.	Control and shut-off valve	Manual or solenoid operated	¼ in.	Stainless steel	450 lb/in²	For radioactive circuits.	Supplied to the UKAEA for the fuel element testing loop of Pluto
Dewrance and Co. Ltd.	Parallel slide valves, with telescopic bellows		3–22 in.	Cast body, forged branches		Steam generating plant and reactor circuits	Valves supplied to Calder Hall, Chapelcross, Berkeley, Bradwell, Hinkley Point, Hunterston, Latina, AGR Windscale, Dreadnought, Pippa loop Harwell
	Screwdown stop valves, bellows sealed or single or double packed gland		1½ in., an alternative design in sizes 2 in. and over has an inclined spindle for lower pressure drops	Forged steel			
	Non-return valves, staggered design of globe valve		1 in.	Forged steel			
	Butterfly valves (Bodies fabricated by Babcox and Wilcox Ltd.)		8–42 in.			For regulating, bypass	For Berkeley
Drayton Regulator and Instrument Co. Ltd.	Butterfly, on/off, proportional mixing and diversional, self-operating, reducing	Diaphragm, motorized or electrical	½–12 in. Larger sizes available	Cast iron, gunmetal, forged steel, cast steel. Stainless steel, and nickel alloy trim	900 lb/in² 900°F	Pressure temp. mixing, control of gases and fluids	Supplied to UKAEA
Edwards High Vacuum Ltd.	Magnetically operated vacuum valves		¼–2 in.		Max. pressure differential 1 atmosphere	Vacuum control of non-corrosive gas or vapour	
	Quarter swing butterfly valves		1–6 in.	Stainless steel			
	Diaphragm-type valves		½–3 in.	Die-cast mercury resistant light alloy			Based on the Saunders valve
	Isolation and baffle valves						
	Gate valves	Pneumatic operation	9, 12, 16, 24 in.	Mild steel		Vacuum systems associated with particle accelerators	16 and 24 in. supplied for the 7 GeV proton synchrotron at Harwell
	Ultra high vaccuum valves		½, 1 in.			For use with controlled thermo-nuclear applications	
George Ellison Ltd.	'Ellison' d.c. double solenoid valve		½ in. ports		Pressure controlled by valve 600 lb/in²	Controls pressure for tight sealing 60 in. main duct valves	Supplied to Berkeley
	2-way screwdown valves	Hand-operated	¼ and ⅜ in. ports		12,000 lb/in² at 450°F		Supplied to Risley
	'Ellison' 4-way d.c. solenoid-operated valves		½ in. ports		1000 lb/in²	For controlling reciprocal action equipment	Supplied to Windscale
Ether Ltd.	Single or double port valves	Air or solenoid operated	½ in. ports	Body: brass, gun-metal, cast iron, forged steel, stainless steel, plastics Iron circuit: 48% Ni-Fe alloy Top trim: Cu-Ni alloys or stainless steel	250°C	Process control	Supplied to the UKAEA
The Farringdon Works and H. Pontifex and Sons Ltd.	CO_2 reducing valves and plugcocks			Non-ferrous mainly gunmetal	Outlet pressures up to 200 lb/in²		Supplied directly to the UKAEA and to sub-contractors
Farris Engineering Ltd.	Safety and relief valves			Body: cast steel Internals: stainless steel		For chemical processing applications	Supplied to the UKAEA
Flight Refuelling Ltd.	Electrically actuated shut-off valves		2½ in.	Mild steel protected by phosphate and Dag. Smaller sizes in stainless steel		Radioactive gas circuits	Supplied to the UKAEA
	Non-return valves		¼–6 in.				
	Quick-release self-sealing couplings and mating adaptors		½, ¾, 2½ in.				
	Special purpose valves and couplings						

MANUFACTURER	DESCRIPTION AND TYPE	CONTROL	SIZE	MATERIALS	OPERATING PRESS. AND TEMP.	APPLICATIONS	REMARKS
Foxboro-Yoxall Ltd.	Control valves	Pneumatically operated		Cast iron, mild steel, forged steel, stainless steel		Process control	
Glenfield and Kennedy Ltd.	Parallel faced valves		60 in.				Supplied to GEC-Simon Carves for Hunterston
Guest and Chrimes Ltd.				Gunmetal and cast iron		For oil circuits and C.W. circuits	
James Gordon (Valves) Ltd.	Patented ' bridge-type ' butterfly valve		6 in. upwards	Cast steel bridge and vane, shaft stainless steel	315 lb/in²		Supplied to Bradwell
Ham, Baker and Co. Ltd.	Sluice valves, and penstocks, reflux valves			Cast iron, gunmetal, steel castings for high pressure applications		C.W. water control	Supplied to Calder Hall, Dounreay, Chapelcross, Windscale, Hunterston, Bradwell, Berkeley and Risley
Hattersley (Ormskirk) Ltd.	Renewable disk globe check valve	Manual		Gunmetal	200 lb/in² at 388°F	Steam service	Supplied to UKAEA
	Solid wedge sluice valves	Manual	10 in.	Gunmetal	125 lb/in² (water)		Supplied to UKAEA
	Swinging check valve		½, ¾, 1 in.	Gunmetal	125 lb/in² at 353°F	Steam service	Supplied to UKAEA
	Reflux valve		7 in.	Cast iron	175 lb/in²		Supplied to UKAEA
	Solid wedge sluice valve	Manual	8 in.	Cast iron, wedge faced with gunmetal			Supplied to UKAEA
	Three-way gland steam cock	Manual	½ in.	Gunmetal	150 lb/in²	Steam service	Supplied to UKAEA
	Globe valve	Manual	Up to 3 in.	Special flexible titanium alloy disk, seat of nickel alloy	200 lb/in² at 500°F	Steam service	Supplied to UKAEA
High Pressure Components Ltd.	Screwdown valves Relief valves (stainless steel bellows)	Manually operated	½ in. 1–1½ in.	Stainless steel	Up to 600°C 1000 lb/in² (on nitrogen)	Radioactive gas circuits	Supplied to UKAEA
W. C. Holmes and Co. Ltd.	Double disk and parallel slide valves	Hand operated	3–48 in.	Cast iron, spindle and springs of stainless steel	Medium pressures, up to 200°C or 400°C when fitted with special springs		Supplied to AEE Winfrith
Honeywell Controls Ltd.	Globe type, double seated, bellows sealed		1–12 in.	Stainless steel body and trim	max. 750°F 3–60 16/in²	Used on acid lines	Supplied to UKAEA, Capenhurst
Hopkinsons Ltd.	' Tansphere ' butterfly valves	Electrically operated	36–6 in.	Bodies and covers of steel, iron or bronze.		Isolating valves for main gas ducts	
	Deadweight relief valves		20 in.	Valve disks, heads and seats of a Ni alloy (Platnam)		For dump steam	Supplied to Calder Hall and Chapelcross
	Other valves supplied: safety valves, blowoff valves for heat exchangers, parallel slide valves desuperheating equipment, and isolating valves for CO_2 handling systems (Bradwell)						
Hymatic Engineering Company Ltd.	Air and CO_2 reducing valves			Light alloy	Inlet 100 lb/in², outlet 9 lb/in² Temp. range −40/+125°C	Gas control	Supplied directly to UKAEA and the consortia
Koswa Ltd. (Valves)	Oblique valves (straight through flow)		½–10 in.	Gunmetal or Meehanite cast iron	Up to 250 lb/in² (at 250°F), 150 lb/in² (550°F)	Water, steam, gas, oils	
	Direct acting mixing and control valves		½–8 in.	Gunmetal or Meehanite cast iron	Up to 250 lb/in²	Water, steam, gas, oils	
Richard Klinger Ltd.	Sleeve packed manifold cock		½–1 in.	Bronze, forged or stainless steel		Sampling control	Supplied to the UKAEA
Lang Pneumatic Ltd.	BSP pilot valves 2-, 3-, 4-way units	Hand, air, and solenoid operated	¼ in. Up to 1¼ in.	Hot brass stampings, gunmetal castings, stainless steel, cast iron, mild steel, Viton A rubber for applications up to 200°C		Control valves	Supplied to Edwards High Vacuum for Harwell and to C. A. Parsons for controlling charge and discharge valves
Langley Alloys Ltd.	Gate and globe valves			Stainless steel		For effluent disposal plants and heavy water handling	Supplied to UKAEA, Harwell, and for reactors in Denmark and Australia, Belgium heavy water plants, and on coffin decontamination plants

Laycock Engineering Ltd.	Magnetic solenoid valves		¼ in. outlet	Body, bronze; plunger and spring stainless steel	Up to 200 lb/in²		Supplied to UKAEA
Leybold Vacuum Sales Ltd.	Diaphragm valves	Hand operated		Light alloy		High vacuum systems	Supplied to UKAEA
The Magnetic Valve Co. Ltd.	Single beat stop valves High and low pressure stop valves		½–12 in.			Automatic or semi-automatic control of water, steam, oil	
Martonair Ltd.	Piston valves Poppet valves	Pneumatic or hydraulic		Brass, aluminium		Used on remote handling equipment	
Merrill Pumps Ltd.	Straightway and multiport sleeve diaphragm stop valves and regulating valves. Holding up or non-return valves. Sleeve diaphragm pressure relief valves			Cast iron, lined with rubber, hypalon or polythene, stainless steel, porcelain PVC ebonite, polythene, hypalon, butyl, neoprene, viton, etc.	Up to 300 lb/in²	For chlorinated water and radioactive effluent	Supplied to Head Wrightson and Co. Ltd. for Bradwell
Meynell and Sons Ltd.	'Rayon-Patent' glandless valves	Hand operated or remotely controlled		Stainless steel, aluminium, gunmetal or cast iron lined with hard or soft rubber, glass, plastic or nylon. Steel spindles and pressure plate around which is bonded rubber or synthetic rubber		Control of corrosive fluids	Supplied to UKAEA
	Steam/water mixing valves			Body and cover of cast gunmetal, steam valve of Monel with Fluon seat		Process work and ancillary services	Supplied to UKAEA
Mucon Engineering Co. Ltd.	Control valve (acting on iris diaphragm principle). Also used as glandular seal		½–18 in. standard (special up to 12 ft)	Body in aluminium, gunmetal or stainless steel, Diaphragm in nylon, terylene, p.t.f.e., rubber, and special coated fabrics	Up to 280°C 10 lb/in²	Handling powders, granular or lumpy solids, slurries, water at low pressure, air control and dust extraction, safety seals for radioactive gases	Supplied to Risley, Springfields, Calder Hall, Windscale and Trawsfynydd
Neidco Processes Ltd.	Pinch valves					Slurry flow control	Supplied to US nuclear power stations
NGN Electrical Ltd.	Electromagnetic valves Hand valves (straight through and right angle type)		¼–4 in. ½–2 in.	Brass and mild steel all internal parts nickel plated		For high vacuum operation	Stores items at Aldermaston and Harwell, and also supplied to Dounreay for use in gas lines
C. A. Norgren Ltd.	Pressure regulators		¼–1 in.	Brass body and bonnet, synthetic rubber seat	400 lb/in². Max. delivery press. 100 lb/in², Temp. −40/+200°F	Suitable for liquids and air	Supplied by the UKAEA
N.V. Tools Ltd.	Precision pressure relief valves		½–1¼ in. entry	Stainless steel, clack portion in PVC or PTFE	Max. 200 lb/in²	Disposal of corrosive slurries, relief of high press. and superheated steam, compressed air up to 4000 lb/in²	Supplied to the UKAEA under sub-contract
Paintine (Surbiton) Ltd.	Process valves		½ in.	18/8/1 stainless steel, disk rubber. Also in nickel or monel, disk in p.t.f.e.	Vacuum to 50 lb/in² Temp. range—−80/+250°C with p.t.f.e.	Low temp. gas or vacuum applications	Supplied to UKAEA, Dounreay
					Vacuum up to 150 lb/in² at ambient temps. Temp. up to 500°C under vacuum conditions	High vacuum systems or gas applications	Supplied to Harwell and Aldermaston
	Double bellows sealed general purpose valve		¼–½ in.	Contact items in 18/18/1 stainless steel, bonnet, cast steel	Vacuum to 350 lb/in² (dependent on temp.) 500°C max. (dependent on press.)	For vacuum or pressure fluid applications	Supplied to UKAEA, Dounreay
	Liquid metal valve		½–½ in.	Contact items in 18/18/1 stainless steel forgings	Vacuum to 350 lb/in² (dependent on temp.) 400°C (dependent on press.)	Liquid metal circuits	Supplied to UKAEA, Capenhurst
	Bellows sealed metallic oxide valve	Air operated	1, 1½ in.	in stainless steel, nickel, or monel	Vacuum to 50 lb/in² up to 350°C	For handling beryllium chloride and sodium chloride	Supplied to UKAEA, Springfields

Other valves supplied to the UKAEA are remotely operated valves for sampling highly active liquors through shielded cell walls. Automatic 21 in. dia. ventilation control valves for fast reactor

MANUFACTURER	DESCRIPTION AND TYPE	CONTROL	SIZE	MATERIALS	OPERATING PRESS. AND TEMP.	APPLICATIONS	REMARKS
Plessey Nucleonics Ltd.	7 port selector valve 9 port selector valve 16 port shut-off assys. 25 port manual and electro operated 40 port selector valve 54 port selector valve 288 port selector valve			Lead free mild steel and hardening steels of compatible stainless steel and graphite		Reactor gas sampling equipment	Supplied to UKAEA and the consortia
	Shut-off valve (float chamber type)			Stainless steel, body made from Perspex to facilitate inspection		Effluent monitoring equipment	Supplied to the UKAEA
	Shut-off valves, manual with visual indication or combined with differential pressure switch			Lead free mild steel		b.s.d. equipment	Supplied to the UKAEA
Sandall Precision Co. Ltd.	Process gas valves, boron protected cam operated valves, bellows valves, diaphragm valves		¼–2 in.	Steel, stainless steel, Inconel, Monel, brass		Chemical separation plant	Supplied to the UKAEA
Saunders Valve Co. Ltd.	Diaphragm valves			Stainless steel, diaphragm of neoprene, butyl, rubber, polythene, p.t.f.e.		For circuits handling rare gases and radioactive fluids	Used on water treatment plant, fuel element preparation plant, handling heavy water, and argon at various UKAEA plants
Spembly Ltd.	Needle valves Low pressure relief valves		1 in.	Light alloy body stainless steel spindle PVC		For use with pressure ventilated clothing and air supply equipment	Used by the UKAEA for beryllium processing plants
Teddington Aircraft Controls Ltd.	Parallel slide valve, bellows sealed Butterfly valve, bellows sealed	Hydraulically operated Motorized	6 in.	Cr-Mo steel Cr-Mo steel	320 lb/in²g, 475°C	Gas circuits	Used on the AGR test loops
Trent Valve Co. Ltd.	Control valves and gate valves			Stainless steel and forged steel			Supplied to the UKAEA and for the charge/discharge machines at Berkeley
Vacuum Research (Cambridge) Ltd.	Right angle butterfly valves Isolation valves Gate valves	Manual or air operated	Up to 30 in.	Mild steel, stainless, non-ferrous		High vacuum applications (linear accelerators)	
Walker, Crosweller and Co. Ltd.	Steam/Water Thermostatic mixing valves		Up to 2 in. outlet			For ancillary services	Supplied to UKAEA
The Watson-Marlow Air Pump Company	Plugcocks		⅛ in. (up to 1¼ in.)	Fluon	250 lb/in² (cold)	Control of corrosive liquids and gases	Supplied to the UKAEA and USAEC
	Combined needle fine control and stop valves		Up to ¼ in.	Fluon	250°C	"	"
Weir Valves Ltd.	Screwdown wedge gate valves and parallel slide valves, Bellows sealed			Aluminium, brass cast steel, stainless steel, and low-carbon alloy steels. Seating in p.t.f.e., rubber, stainless steel, and stellite. Bellows in brass, Ni, or stainless steel			Supplied to UKAEA, Capenhurst, Dounreay, and AGR
Westinghouse Brake and Signal Co. Ltd.	Magnet valves On/off valves	Air or solenoid operated Pneumatically operated	⅛ in. bore ¼, ½ in.	Cast iron and brass Aluminium, stainless steel		Electro-pneumatic control equipment for emergency discharge pipe	Supplied or being supplied to nuclear power stations
	Globe valves		1½–6 in.	Phosphor bronze, stainless steel			
	Charging valve Unloader valve ' Pop ' type safety valves Reducing valves			Aluminium alloy, steel Cast iron, stainless steel, brass Brass, stainless steel Aluminium		Electro-pneumatic control equipment for flask handling equipment and for manipulator plant and emergency discharge gate	
	Double check valves Diaphragm valves Relay valves			Brass Aluminium Cast iron, brass			

The following firms also supply valves to the atomic energy industry:

Blundell and Crompton Ltd. **Electro-Hydraulics Ltd.** **Gummers Ltd.** **Newman Hender & Co. Ltd.** **K.G.**
British Steam Specialties Ltd. **Fisher Governor Co. Ltd.** **Joshua Hindle & Sons Ltd.,** **Stahl-Armaturen Siepmann G.m.b.H.** **Vickers Armstrong (Engineers) Ltd.**

Moscow under control

P. K. M'PHERSON of the AEA, Winfrith reports on the first Ifac Congress

NEARLY 300 PAPERS were presented at the congress, of which 28 were from Britain. The papers were grouped under three main headings: Theory, Components, and Applications, and were further subdivided into 21 specialized subjects for discussion.

Theory

The papers on the theory of continuous non-linear systems and stochastic problems are applicable to reactor control analysis, particularly when they combine in the theory of statistical linearization for non-linear systems as discussed by I. Y. Kazakov (USSR) (*1*) and Y. Sawaragi (Japan) (*2*). Describing functions received their first rigorous treatment of mathematical validity from R. W. Bass (USA) (*3*).

The greatest general interest was centred on the theory of Adaptive Systems. A memorable discussion followed J. E. Gibson (U.S.A) (*4*) who considered the central problems of adaptive design: definition of the optimum, organization of the system to probe its own performance and then to drive itself into the optimum state. An exciting extension of the idea was suggested by R. I. Stakhovsky *et al* (USSR) (*5*) who described methods for automatic synthesis.

The Principle of Invariance—a Russian preserve—came in for considerable attention: the coefficients of a system's differential equation satisfy the conditions for invariance when the error is identical to zero. V. S. Kulebakin (USSR) (*6*) discussed the theory, and B. N. Petrov (USSR) (*7*) its design applications. In general, conditions of invariance can only be realized in complex systems, particularly combined systems (control by both input disturbance and output deviation).

Transfer function estimation

The problem of recording the performance, and then determining the transfer function of a system was studied closely, several papers being read on frequency response and statistical techniques. Two interesting developments were described, one by T. Kitamori (Japan) (*8*), which minimizes the mean square error between the system output and a variable transfer function generator with orthogonal transfer elements, and the other by V. V. Solodovnikov *et al* (USSR) (*9*), which generates the transient response characteristic of the system under operating conditions. Both methods can be used as part of a self-optimizing control system.

Computers

Three papers on computers were worthy of note. W. J. Karplus (U.S.A.) (*10*) described a network type simulator for the solution of transient field problems incorporating the diffusion equation, wave equation etc. It differs from conventional network analysers as both time and space are approximated by finite difference expressions. Another method of solving boundary value problems on an analogue computer was given by Kuei Chuang *et al* (USA) (*11*). Using 'Monte Carlo' techniques, a considerable economy of computer components is achieved compared with the finite difference method. A useful and surprisingly simple computer for solving functions of a complex variable was presented by M. Morgan (USA) (*12*). Amongst other facilities it can plot the root locus, phase locus and frequency response for systems with up to 60 poles and zeros.

One thousand delegates from 28 countries converged on Moscow between June 27 and July 7 to attend the first congress sponsored by the International Federation of Automatic Control. The first week was devoted to the presentation of papers at the Moscow State University, the second week was spent visiting selected scientific institutes and factories in Moscow, Leningrad and Kiev.

The electron has yielded to a particle of air in a range of pneumatic computer and servo devices developed by the Russians. These apparently robust and reliable units have been found suitable for systems and processes with slow responses.

Reactor control

Seven papers were read on reactor control and simulation, among which J. Pottier (France) (*13*) described a transfer function analyser for reactors in which a very low frequency bandpass filter is used to obtain a high signal to noise ratio. The filter is derived from an electrical analogue of the mathematical logarithm in Fourier analysis.

Rechberger and Sequenz (Austria) (*14*) presented an interesting simulation of neutron production with a digital model using novel techniques. The model is fitted with A-D and D-A converters allowing passive networks to represent delayed neutron and reactivity feedback effects. A paper looking into the future of reactor control was read by J. Weill and G. Friedling (France) (*15*). A logical extension is the application of adaptive control to programme the reactor to ensure maximum efficiency for the desired objective.

Automatic control in Russia

There was a lack of complete automation in the factories on view: automation seen amounted only to transfer machines in most cases. The Russians have done important work, however, on control in the steel and power supply industries, and appear to be applying adaptive control by stages throughout industry. They have considerable leeway to make up on digital computer techniques if the two that we saw at the computing centre of the Institute of Mathematics are any guide. Although only a year old they could not provide any of the advanced facilities that the West could expect in machines of the same age. Finally, much of the equipment in the laboratories that we saw looked coarse and shoddy. The visits to the Institutes were, however, in many cases, stimulating; the Institute of Automation and Telemechanics, a post-graduate research centre opened in 1939, particularly aroused considerable interest.

Selected papers

1. Kazakov, I. Y., Problem of the theory of statistical linearization and its applications.
2. Sawaragi, Y., Sugai, N., Sunahara, Y., A statistical study on the analysis and synthesis of non-linear automatic control systems subjected to random inputs.
3. Bass, R. W., Mathematical legitimacy of equivalent linearization by describing functions.
4. Gibson, J. E., Self-optimizing on Adaptive Control Systems.
5. Stakhovsky, R. I., Fitsner, L. N., Shubin, A. B., Automatic optimizers and their use for solving variational problems and for automatic synthesis.
6. Kulebakin, V. S., The theory of invariance of regulating and control systems.
7. Petrov, B. N., The invariance principle and the conditions for its application during the calculation of linear and non-linear systems.
8. Kitamori, T., Applications of orthogonal functions to the determination of process dynamic characteristics and to the construction of self-optimizing control systems.
9. Solodovnikov, V. V., *et al*, Analysis and synthesis of automatic control systems by means of computers.
10. Karplus, W. J., The discrete-space-discrete-time computer; a general purpose transient field simulator.
11. Kuei Chuang, Kazda, L. F., Kindeknecht, T., A stochastic method of solving partial differential equations using an electronic analogue computer.
12. Morgan, M., A new computer for algebraic functions of a complex variable.
13. Pottier, J., Transfer meter for nuclear reactors.
14. Rechberger, H., Sequenz, H., Simulation of a nuclear reactor by a digital model.
15. Weill, J., Friedling, G., Automatic control in nuclear reactors—self-optimizing system.

Stahl-Armaturen Siepmann G.m.b.H. Vicker Armstrong (Engineers) Ltd.
Joshua Hindle & Sons Ltd.,
Fisher Governor Co. Ltd.
British Steam Specialties Ltd.
60

For the efficient running of power reactors, such factors as regenerative feed heating, superheat and reheat can play an important part

Steam cycles for power reactors - I

by W. J. THOMAS, B.Sc.(Eng.), A.M.I.Mech.E., A.M.I.E.E., Mem.A.S.M.E.
Kennedy & Donkin

THE THEORETICAL basis for steam turbine cycles is the well-known Rankine cycle (Fig. 1) in which the cycle work done and the heat supplied are shown by areas *a b c d e* and *x a b c d y* respectively. The cycle efficiency can be increased by either enlarging the "work done" area or reducing the "heat supplied".

In modern advanced cycles both these aims are achieved by employing higher boiler pressures, lower condenser vacua, regenerative feed heating, steam superheating and reheating. Fig. 2 shows the cycle of a regenerative feed system, in Fig. 3 superheat has been added, and Fig. 4 shows the addition of reheat.

Turbine steam expansion

In the diagrams of this article, the expansion of steam through the turbine has been considered to be adiabatic and at constant entry, from turbine stop valve to condenser vacuum. In practice this is not so, due to the inefficiency of the blade system, and this causes an increase in entropy as the steam expands through the turbine.

The increase in entropy for a single stage can best be appreciated by considering Fig 5, a stage where the inlet conditions are pressure P_1 and temperature T_1; if the steam is expanded adiabatically to a pressure P_2 then the temperature would be T_a, and the adiabatic heat drop H_1. Due, however, to friction between the steam and the blade system, it would be found in practice that, at the pressure P_2 the temperature would be T_2 which is higher than T_a, and that the heat drop over the stage was represented by H_2. The internal efficiency of the stage is then defined as H_2/H_1 and this will vary with the steam volume passing through the stage and the ratios of pressures between the inlet and outlet.

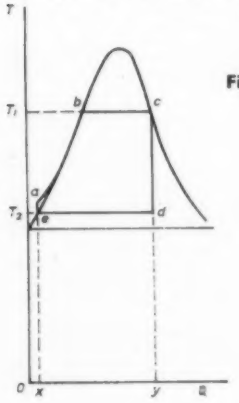
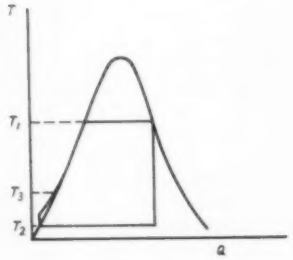


Fig. 1 (left) The Rankine cycle

Fig. 2 (right) The Rankine regenerative feed cycle



Some figures of internal efficiency to be expected have been published in ref. (*1*) and are shown as Fig. 6. In this diagram the internal efficiency to be expected by machines of General Electric of America is demonstrated, and is valid for machines rotating at 3600 rev/min operating in the dry region and is not applicable to the governing stage. When expansion of the steam passes into the wet region, that is below the saturation line, there is a reduction in the stage efficiency below that attainable in the dry region by an amount equal to 1% for each 1% of mean moisture in the stage.

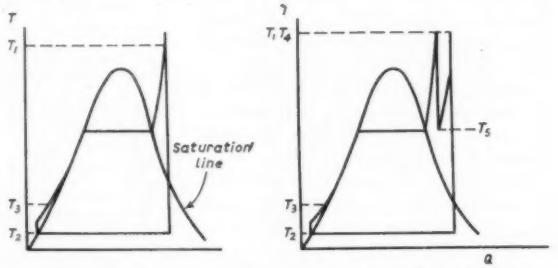


Fig. 3 (left) The Rankine regenerative feed cycle with superheat. **Fig. 4** (right) the same cycle with superheat and reheat

Figure 7 shows a total heat/entropy diagram, or Mollier chart as it is more familiarly known, upon which have been added a typical expansion line which runs adjacent to the large number of varying steam conditions which have been used over the years of development of the steam turbine, together with expansion lines which may be expected from operating with saturated steam. The lines have been drawn assuming an 85% internal efficiency in the dry region and the reduction from this level by an amount mentioned above when operating in the wet region.

It is clearly shown from the typical expansion with a condenser vacuum of 0·5 lb/in²a and for all the operating conditions used as a general rule, that the wetness at the exhaust of the turbine does not exceed 14%. This figure is used as a limiting factor in the design of steam turbines. Even when wetness fractions less than this are expected, shields are provided of very hard material to protect turbine blades from the erosion troubles which such high wetness steam can cause.

Accepting 14% as the limiting factor for exhaust wetness, any system which is designed with steam conditions

much to the left of the typical straight cycle will require some means of ensuring that the figure mentioned is not exceeded. Many methods are available for accomplishing this and they will be discussed when considering the cycles which have been adopted with various reactor systems.

Steam cycle economics

The aim of the designer to evolve a power producing system which is of high reliability at cheapest possible cost, is intimately tied up with economics which can be subdivided into capital costs and the running costs. The capital cost incurred dictates the performance which can be obtained from the station while the performance will dictate largely the running costs. There is therefore an optimum which enables power to be produced at cheapest cost and the effect of the thermodynamic principles, which were discussed earlier, on the economics of the system, can now be examined.

Any increase in thermal performance of a steam cycle can be considered under the following headings:

1. Increase of stop valve pressure
2. Increase of stop valve temperature
3. Provision of reheat
4. Increase in final feed water temperature
5. An increase in vacuum.

The essence of increased performance is that for a given power output less fuel is used. This results in progress if the extra capital costs involved in producing the better performance does not exceed the savings made. The criterion for opitmization is, in the eventual station, that the total cost per unit shall be the lowest possible. This in fact does not represent lowest capital cost or highest thermal performance but a balance between both.

The savings in operating costs by the provision of the five above mentioned items will result in complications to the design as follows, which have to be considered in an economic assessment.

Increase in stop valve pressure This will involve increased metal thickness to contain the pressure in steam raising unit and piping with resulting increased costs in capital. The pressurizing of the working fluid to a higher level will also involve the use of feed pumps which will consume more power and this is reflected in the operating cost.

Increase in stop valve temperature An increase in temperature decreases the creep properties of metals. Each increase in temperature has to take account of this effect and results in extra capital costs. The quality of water supplied in the steam cycle has to be closely controlled

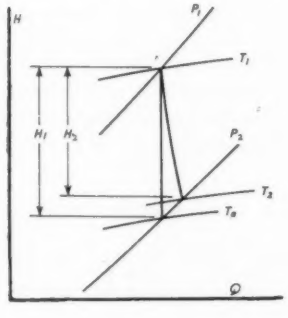


Fig. 5 Typical turbine expansion showing the effect of increase in entropy where pressure (P_1) and temperature (T_1) are inlet conditions

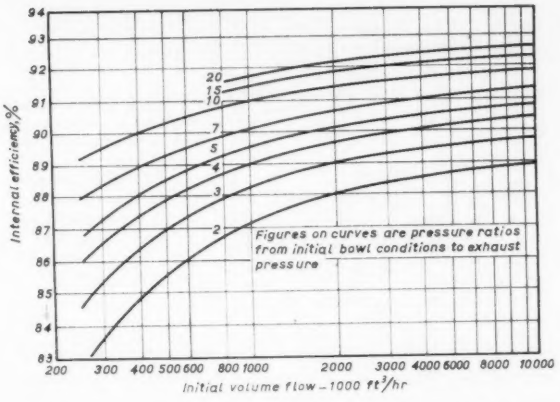

Internal efficiency, %
Initial volume flow – 1000 ft³/hr
Figures on curves are pressure ratios from initial bowl conditions to exhaust pressure

Fig. 6 Internal efficiency exemplified by General Electric machines

when high temperatures and pressures are involved. Extra costs are therefore likely to be met in the preparation of high quality water and on the services involved in maintaining high standards.

Reheat The use of reheat has a profound effect on performance with resulting complication to the plant. The loss of pressure over a reheater is a loss to the system performance. The optimization of pipe sizes is, therefore, of importance together with ensuring that the shortest possible lengths are used.

Increase in final feed water temperature This will involve a modification in the design of the turbine to allow for an extra tapping point on the turbine together with the provision of an extra heater or heaters.

Increase in vacuum To obtain a better vacuum, extra surface will be required in the condenser together with the provision of extra circulating water with resulting increase of power requirements. An increase in vacuum also has a pronounced effect on the area of the last rows of the turbine. The velocity leaving the last stage represents the

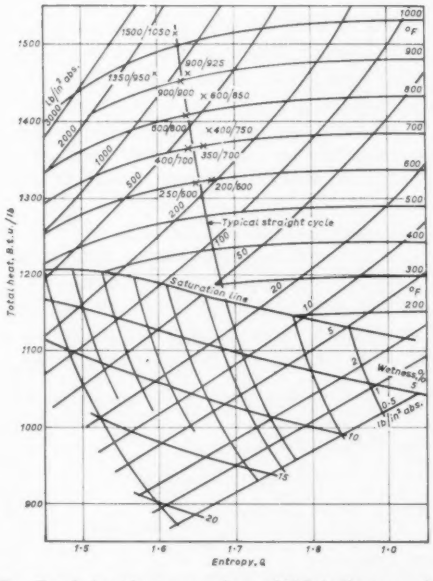


Fig. 7 Total heat/entropy chart. 'X' indicates selected classic inlet conditions (lb/in²g, °F)

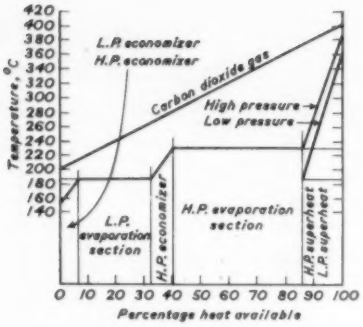


Fig. 8 Dual pressure heat exchanger. Variations of coolant gas and working fluid temperatures for heat transfer

leaving loss and any increase in vacuum increases the leaving loss. The area of the last row of blades must, therefore, be such to have an economical leaving loss. It follows that any increase in vacuum must be balanced by increased size of this part of the turbine, with a resultant increase in cost.

Cycles associated with British reactors

The basis of the British programme of atomic power development is the use of natural uranium clad in magnox cans, moderated by graphite and cooled by carbon dioxide gas. The main factor in the design of a steam cycle associated with such reactors is the bulk outlet temperature of the carbon dioxide gas. This is limited to approximately 400°C (752°F) due to metallurgical conditions of the natural uranium fuel element and its associated magnox can. The second factor which dictates the steam conditions that can be used with such a reactor is the heat exchanger outlet temperature or reactor bulk inlet temperature. This has to be chosen with regard to the power consumed in circulating the gas. The higher the temperature for a given output, the higher will be the circulating power with resulting decrease in net output for the station. An optimization study has, therefore, to be carried out in regard to this temperature, together with the added factor that high temperatures inhibit Wigner energy problems.

The first round of seven British reactors being built at Bradwell, Berkeley, Hunterston, Hinkley Point, Latina, Tokai-Mura and Trawsfynydd each utilize a steam cycle using steam at two pressures. At each pressure superheated steam is produced, the high pressure steam being supplied direct to the turbine while the low pressure steam is introduced into the system to join expanded high pressure steam.

The dual pressure steam cycle makes most effective use of the heat available from the reactor. The use of a single pressure cycle would result in the production of very low pressure steam with resulting loss in cycle efficiency. Utilization of a triple pressure cycle would result in more efficient operation, but the added complications with resulting increase in capital costs do not justify its use at present.

TABLE 1 *Performance Data. Hunterston Nuclear Station*

Reactor heat output	568·8 MW
Heat to gas from circulators	12·3 MW
Total heat to gas	581·1 MW
Heat losses from reactors and external circuits	2·7 MW
Heat transferred to steam	578·4 MW
Gross electrical power generated	184·1 MW
Circulator power consumption (rectified transformer input)	14·5 MW
Power consumption of other auxiliaries	5·3 MW
Net power sent out	163·8 MW
Overall 'sent out' efficiency (9/1)	28·8%
Turbine house efficiency (6/5)	31·8%

The advantage of the dual pressure cycle over a single pressure cycle is due to the fact that approximately 65% of the total steam flow to the turbines is generated at high pressure. In the systems under consideration, the most effective heat transfer takes place with minimum temperature difference between the heat exchanger fluids. With a low or medium pressure steam cycle the majority of heat transferred is that associated with the supply of latent heat in turning water into saturated steam which is done at constant temperature. To obtain the maximum effectiveness of the heat available in the reactor coolant gas an infinite number of pressures should, therefore, be used. This of course is not practicable and economic assessments have adjudged that the dual pressure cycle is the most effective at present day costs.

Fig. 8 shows the heat transfer characteristics of a heat exchanger associated with a dual pressure cycle. This is typical and represents the condition being used at Hunterston Station being erected by the General Electric Company for the South of Scotland Electricity Board (*2*).

With a feed temperature from the turbine of 148°C, 67% of the total steam generated is high pressure steam at a pressure of 578 lb/in²g and 385°C, while the remaining steam is generated at low pressure at 147 lb/in²g and 362·8°C. These figures represent the steam conditions at the heat exchangers. They are slightly lower at the turbine stop valves.

TABLE 2 *Performance Data. Dungeness Nuclear Station*

Net electrical output/reactor	275 MW
Heat output/reactor	835 MW
Overall 'sent out' efficiency	32·9%
Reactor bulk outlet temperatures	770°F (410°C)
Reactor gas inlet temperature	482°F (250°C)
H.P. steam temperature at blower T.S.V.	1410 lb/in² a
H.P. steam temperature at blower T.S.V.	738°F (392·2°C)
L.P. steam pressure at main T.S.V.	550 lb/in² a
L.P. steam temperature at main T.S.V.	736°F (391·1°C)
Final feed water temperature	356°F (180°C)
Vacuum at exhaust	28·9 in. Hg.

Table 1 represents the performance expected of one of the two reactor systems to be installed at Hunterston.

The application of re-heat in the 550 MW output station at Dungeness, for which a recent Letter of Intent was issued by the GECB to the Nuclear Power Group, is of interest.

The information published on this station (*3*) shows that although the dual pressure cycle has been used, its application is an advance in thermal performance on its predecessors (see Table 2).

Steam generated in the high pressure section is used to drive the four blowers associated with circulating the carbon dioxide gas. The steam is expanded to the pressure corresponding to that used for the main single pressure turbines, where before passing to the turbines it is reheated to its original temperature.

This system of reheating becomes feasible when such a system is used, as the high pressure steam is used adjacent to the heat exchangers and long lengths of steam piping with their inherent pressure drops are eliminated.

References

1. Bartlett, R. L. Steam turbine performance and economics. McGraw-Hill.
2. Hunterston Nuclear Generating Station. South of Scotland Electricity Board. Jan. 1960.
3. *Nuclear Power*, **5**, 66, August 1960.

The Brookhaven high flux beam reactor

The new research reactor due for completion in 1962 at Brookhaven National Laboratory, is designed to provide intense thermal and resonance energy neutron beams with the highest possible ratio of useful neutron current to gamma ray and fast neutron background

A PRELIMINARY DESIGN has now been made for a new research reactor at the US Brookhaven National Laboratory. The concept employed has an undermoderated high power density core surrounded by a heavy water reflector. Following earlier studies of the system, (*1*) (*2*), Mr. J. M. Hendrie of the Laboratory included the following details and illustrations in a paper (*3*), to the Summer Meeting of the American Nuclear Society.

The core will employ ETR flat plate fuel elements with an increased uranium loading. The vessel is a 7 ft diameter sphere of aluminium with a 4 ft diameter cylindrical neck of stainless steel. In the system, the power density peaks at the core boundary while the thermal flux rises to a broad peak in the reflector, with the maximum some 4 in. outside the core, and the half maximum flux point 15 in. outside the core (*2*) (*4*). The resonance flux is nearly constant across the core and decreases slowly in the reflector to the half maximum point at 4 in. from the core boundary. The large, high-flux volume in the reflector permits beam tubes to be placed well away from the core (see Figure 1) so that the quality (i.e. the signal-to-noise ratio) of the emergent neutron beams is very high. The beam quality is further improved by placing the beam tubes 'tangentially' so that the core is not viewed directly (*5*) (*6*). An extensive series of critical experiments (*4*) (*6*), show that such a beam tube geometry improves the signal-to-noise ratio of the beam by a factor of 20 to 30, with a reduction in thermal flux intensity of only 1·3.

The eight tangential beam tubes are all of 3·5 in. inside diameter. A large (12 in. i.d.) radial thimble is provided to house a refrigerated moderator block which will be used for 'cold' neutron beams. In addition to the nine beam tubes, there are three thermal flux irradiation thimbles in the reflector, and four fast flux irradiation thimbles in and just outside the core.

Eight exterior corners of the core are covered by control rods. There are 8 main, or safety rods which withdraw above the core, and 8 auxiliary rods which withdraw below the core. The upper and lower sets of rods are maintained at equal distances from the core centre, and thus induce a minimum perturbation of the mid-plane flux. Only the upper rods drop on a scram signal.

With heavy water in the reflector, it is convenient to use heavy water as a coolant as well. The coolant (see Figure 2) enters the neck of the vessel, passing down through the core, and returning up through the reflector.

The reactor building is divided into a basement which houses the reactor and auxiliary machinery, an experimental floor, and an operations floor where all of the fuel and hot sample handling is done. The experimental floor, into which all of the neutron beams are directed, is completely sealed and shielded from the other areas.

HFBR CHARACTERISTICS

Power range	20–40 MWt
Neutron flux:	
*Core, total epithermal	$1{\cdot}6\times10^{15}$ cm^{-2} sec^{-1}
*Reflector thermal flux, max.	7×10^{14} cm^{-2} sec^{-1}
Materials:	
Coolant, moderator, and reflector	D_2O
Fuel	U-235-Al alloy
Core structure, beam tubes, vessel	6061 aluminium
Fuel element, ETR flat-plate type:	
Uranium concentration in fuel alloy	30 wt. %
Fuel and clad thicknesses	·020 and ·015 in.
Fuel region dimensions (element)	2·6×3·0×21·0 in.
U-235 loading per element	260 g
Core details:	
Number of fuel elements	28
Core volume	86 litres
Water-to-metal volume ratio	1·23
*Cycle time for 20% burn-up	40 days
Power density peak/average ratio	3·0
Process design parameters:	
*Primary system design pressure	250 lb/ft² g
*Primary loop pressure drop	250 lb/ft²
*Total D_2O flow rate	17,600 gpm
*Velocity in fuel channels	35 ft/sec
Core inlet temperature	120°F
*Average heat flux	387,000 BThU/h-ft²

**Values appropriate for 40 MWt power*

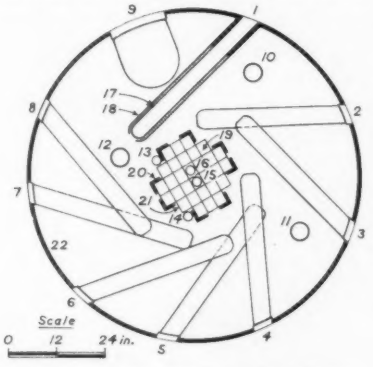


Fig. 1 1. Slow chopper; 2. Fast chopper; 3. Thermal beam; 4. Fast beam; 5. Thermal beam; 6. Thermal beam; 7. Intermediate beam; 8. Thermal beam; 9. Cold beam; 10, 11, 12. Reflector irradiation thimbles; 13, 14. Core edge irradiation thimble; 15, 16. In-core irradiation thimbles; 17. Beam tube; 18. Beam tube cooling jacket; 19. Cell for fuel element (typ); 20. Control rod blade (typ); 21. Egg crate-type shroud (Al); 22. Reactor vessel (Al)

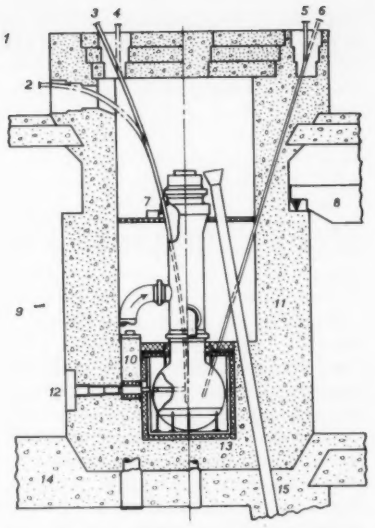


Fig. 2 1. Operations level; 2. Aiternate; 3. Fast flux irradiation thimble; 4. Alternate; 5. Thermal flux irradiation thimble; 6. Alternate; 7. Control rod drive; 8. 20-ton revolving bridge crane; 9. Experimental level; 10. Beam hole shutter; 11. Heavy concrete; 12. Typ. experimental beam hole; 13. Thermal shield; 14. Structural concrete; 15. Fuel chute to canal

References

1. T. Auerbach, J. Chernick, J. Juliens, G. Lellouche, W. Zinn and associates, Preliminary Design of a High Flux, Epi-thermal Research Reactor for the Brookhaven National Laboratory, Proc. Second Int. Conf. Geneva, *1958*, P/424, Vol. 10, p. 60 (1958).
2. P. Michael and W. Rothenstein, Preliminary Theoretical Studies of the Brookhaven Beam Research Reactor, Trans. Am. Nuc. Soc., *2*, 120 (June, 1959).
3. J. M. Hendrie, Preliminary design of the Brookhaven High Flux Reactor, Trans. Am. Nuc. Soc., *4* (Paper No. 1, Session 4) (June, 1960).
4. K. Downes and A. J. Court, Power, Flux and Importance Distributions in the High Flux Beam Reactor Critical Experiments, Trans. Am. Nuc. Soc., *3* (Paper No. 4, Session 10) (June, 1960).
5. F. E. Jablonski and R. S. Carter, A Study of Split Cores for Research Reactors, Nuc. Sci. Engr., *5*, 257 (1959).
6. A. J. Court and K. Downes, Beam Tube Flux Evaluation on HFBR Critical Experiments, Trans. Am. Nuc. Soc., *3* (Paper No. 5, Session 10) (June, 1960).

Etching graphite blocks

automation by shot blasting

For the impregnation of graphite blocks, an acceptance figure of 12% impregnation by weight of bitumous resin against weight of graphite is laid down. To achieve this, the block surfaces require the application of a very even etch after cleaning.

One method of dealing with this problem is by individual hand brushing to remove the baking pack, used in the manufacture of the blocks, and then wire brushing to obtain a form of etch. This method has not proven entirely satisfactory; consequently one firm, British Acheson, have turned to a process previously considered as unsuitable, namely that of grit blasting.

Using the Vacu-Blast dust-free shot blasting equipment, an automatic system has been devised whereby the blocks are conveyed through two pass-through blast cabinets. Both of these cabinets contain two grit blasting nozzles, which, powered by air motors, are set to oscillate sufficiently enough to blast one complete side each as the blocks pass through. Thus, the first cabinet blasts two sides and the second cabinet blasts the other two sides, the blocks being turned as they pass from the first to the second cabinet. The blast from the four nozzles in the two cabinets is powered by a Vacu-Blast Senior Machine which incorporates the Vacu-Blast system of grit reclamation and recirculation. Due to the fairly large amount of graphite dust removed during blasting, two intermediate dust extractors and an auxiliary dust collector are incorporated in the blasting circuit, to deal effectively with the dust and debris.

These main features give a continuous etching process with important advantages over the methods tried before. Impregnation tests have proved that the required 12% figure has, in fact, been exceeded by between 2% and 4% on all blocks tested. With the high standard of etch obtained, any cracks and imperfections present are easily detected visually, thus eliminating the wasteful impregnation of faulty blocks.

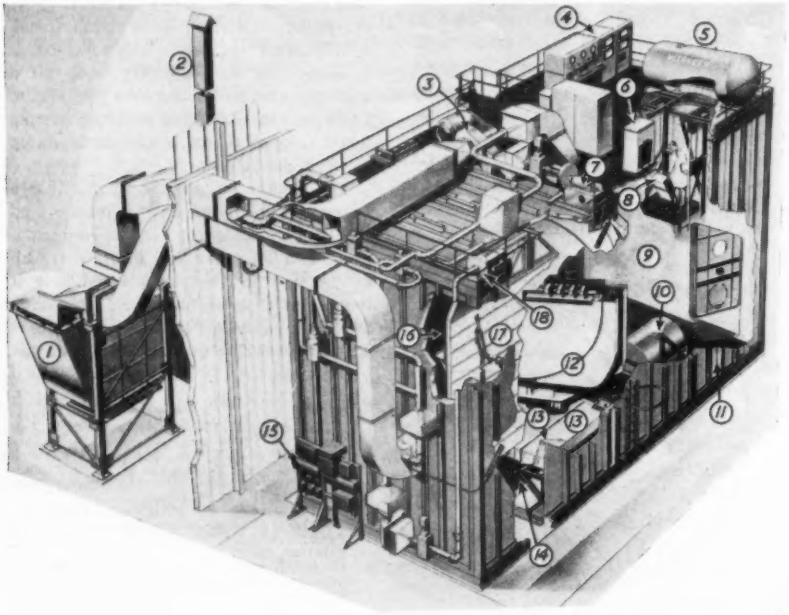
A very significant improvement, however, is the higher processing rate. It has been firmly established that, whereas processing with brushes produced only 10 blocks per hour, grit blasting has increased this output to 80 blocks an hour, the blocks varying in size from 8¼ in. square to 20 in. square with the length 3 ft to 4 ft.

New look for Gleep

Modernization after 13 years

Harwell's Gleep, after 13 years operation, has received an extensive overhaul. Early this year, the original 33 tons of canned uranium oxide pellets and bare uranium bars were unloaded.

To give maximum safety during unloading, the mechanism for fuel ejection



SCORPIO 1 LAYOUT

1 Heat exchanger
2 Exhaust chimney
3 Stack cooling blower
4 Control console
5 Nitrogen reservoir
6 Alpha monitors
7 Differential pressure blower
8 Pre-heat oven
9 Personnel chamber & door
10 Source flask
11 Alpha containment
12 Main & circular doors
13 Heat insulation
14 Graphite plinth
15 Main switch board
16 Graphite stack
17 Electric heater mats
18 Personnel chamber blower

NEW WINFRITH FACILITY Experimental facilities for predicting the changing characteristics of the Calder type reactor caused by burnup will soon be provided at the AEE, Winfrith, by Scorpio 1, a hot exponential assembly, and its companion Scorpio 2, a hot fine structure apparatus. Details are:—

SCORPIO 1

30 × 30 × 20 ft high; graphite: 10 ft³×5 ft³ (varying from 15-30 tons); fuel: U—several tons Pu—several Kg; neutron source: radium beryllium; heating: radiant heater blankets (2); coolant: nitrogen

SCORPIO 2

40 × 20 × 20 ft high (incl. shield) graphite: 5 ft³; neutron source: antimony beryllium

Varying plutonium and uranium, temperature, graphite moderator and lattice geometry, with corresponding measurements of flux and other physics calculations, will facilitate consistent design methods. Scorpio 1, designed to operate up to 400°C, has so far been tested successfully up to 300°C.

Vickers-Armstrong (South Marston) Ltd, who have designed sub-critical assemblies for teaching purposes, are the main contractors.

was designed to supply argon as a blanket to counter fire hazard. At the same time, powerful vacuum cleaners removed particulate matter to reduce friction.

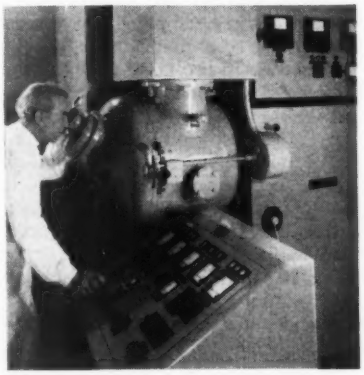
The reactor operates only at 3 kW and residual radioactivity is very low. Consequently, access was possible to the space between the core and the 5 ft thick biological concrete shield.

Reactor instrumentation has now been completely renewed and the two previous control rooms, one for the reactor and one for the experimental facilities, have been combined. The reactor has now been recharged with natural uranium fuel elements canned in aluminium.

High vacuum melting

new electron beam plant

A new method of electron beam melting, developed by Heraus, overcomes the earlier problems created by high



The Heraus all-purpose laboratory plant for electron beam melting enables every known process in this field to be carried out

intensity glow discharges. Accelerated electrons leave the vacuum chamber by a narrow aperture as a parallel or slightly divergent beam, and melting takes place in a field-free chamber, the passage of the lines of force through the aperture being so small as to be negligible. The ions formed as a result of electron impact, therefore, are not accelerated and no glow discharge can develop. In the event of a great deal of gas being evolved during melting, only a small quantity can pass through the aperture into the beam production chamber, thereby eliminating the formation of high-intensity glow discharges.

Since the electrons already leave the gun with a high rate of energy, and because the material to be melted does not act as an accelerating electrode, there is no need for it to have electrical conductivity. Therefore, in addition to metals, it is now possible to purify and degas, by melting in high vacuum, non-conductors such as ceramic materials and semiconductors.

Improved UO_2 fuel elements

thermal conductivity up 30%

A technique for raising the thermal conductivity of uranium dioxide fuel element material by 30% and more has been developed by the Martin Company. Tiny fibres of molybdenum are added to uranium dioxide powder, the mixture is then inserted into thin cans, with the entire assembly swaged to increase the density to between 84 and 87% of theoretical limits.

The work, which was undertaken by Martin's Nuclear Division under contract to the USAEC, was reported to a national meeting of The American Nuclear Society. One paper by John L. Kane and Harold N. Barr described fabrication techniques and a second, by Marvin P. Norin, outlined the results of thermal conductivity measurements of the prototype fuel elements.

Some of the many properties of uranium dioxide which make it attractive as a nuclear fuel are its chemical inertness towards many coolant materials, stability under irradiation, and ability to retain fission products. The disadvantages:—low thermal conductivity, low thermal shock, and low thermal stress resistance, are improved by incorporating it in metal matrices to form cermets or dispersions. However, a considerable amount of metal is required in these types of systems, necessitating enriched fuel.

Metal additions in fibre form allow these improvements to be made with the minimum of added metal. Previous development of metal fibre–ceramic bodies has shown that hot pressing is necessary to produce dense bonded compacts. The programme outlined in the papers showed that canned metal fibre–ceramic fuel rods could be fabricated by the swaging technique.

The concept of a swaged metal fibre–uranium dioxide fuel element has been shown to be feasible in that rod-type fuel elements have been fabricated with up to 20 vol–% fibre content. The addition of 15 vol–% molybdenum fibre showed an improvement of 30% in the thermal conductivity at room temperature, and at higher temperatures even larger improvements can be expected. Analytical calculations for an element with continuous radial fibre distribution have shown that, with a coolant temperature of 315°C, the addition of 15 vol–% of 0·003 in. fibres lowers the core temperature 316°C. With a coolant temperature of 815°C the same addition lowers the core temperature 500°C. It has been found, both experimentally and theoretically, that the effective thermal conductivity increased with larger fibre content and smaller fibre diameter. Preliminary tests on the 20 vol–% addition show that the conductivity appears to be boosted by at least 60%.

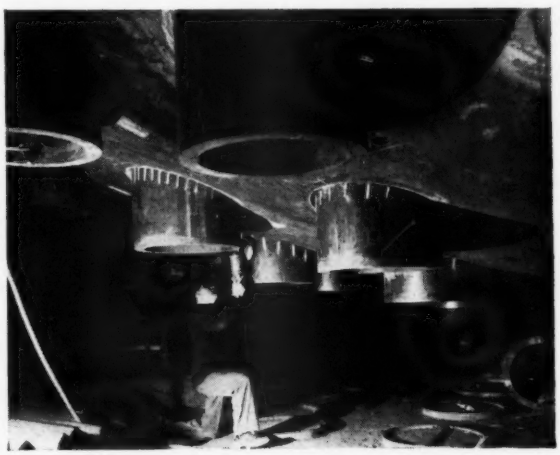
The maximum swaged density was influenced to some extent by the type of canning material used. Specimens canned in type 304 stainless steel, zirconium and zircaloy–2 had similar densities, but those swaged in aluminium showed a loss in density of 2%.

The two methods that proved best for preparing samples with high packed densities and good radial fibre orientation were by pressing a damp mixture of uranium dioxide and fibre in the tube in which it was to be swaged, or by compacting pellets before insertion in the tube. Uniform distribution of the uranium dioxide and fibres was obtained by wetting the fibres and adding the UO_2 during mixing.

Initial tube diameter governed the amount of swaging needed for maximum

FUEL CHARGING AT HUNTERSTON

To facilitate charge and discharge, the reactor's 3288 fuel channels are divided into 101 'charge groups', each having 36 channels. By means of standpipes, that project upwards through the 6½ ft concrete biological shield and the presssure vessel, any one of the fuel channels can be reached. Operations will be carried out by a 37 ft high multi - purpose machine. Under construction by GEC, the pipes are waiting for a final weld



densification, those with a larger initial diameter needing a higher reduction. By combining different sized particles of UO_2, Martin have been able to produce high densities and a good bond between fuel and can with a minimum of swaging reduction. Swaging past the point of maximum densification produced a lower density. Hot swaging increased the density by 2–3%, the best temperature for hot swaging being 800°C.

Largest accelerator works

Brookhaven reaches 30 BeV

Brookhaven's 30 BeV accelerator, an alternating gradient proton synchrotron, was recently operated for a brief trial run at full power after five years construction, although a usable beam of protons has yet to be produced.

Apart from the CERN accelerator, which produces particles of slightly less energy, the only other big machine in the USA is the 6 BeV bevatron at Berkeley. A 12·5 GeV zero gradient synchrotron is under construction at Argonne (see *Nuclear Power* for August, page 97). The Russians have a synchrophasotron that is reported to have reached a power of 10 BeV.

The Brookhaven machine consists essentially of an inconel metal tube, about 7 in. wide and 3 in. high, and half a mile in circumference, contained in a circle of magnets weighing 400 tons.

Canada's steam cooled experiment

NRU to have a UO_2 in-pile loop

Orenda Engines, a member of the Hawker-Siddeley Group, have completed a design for a superheated steam cooled loop to be located in the E.12 lattice position in NRU, Canada's 200 MW heavy water-cooled reactor.

The loop is designed to accommodate the following range of variables:—

Fuel: UO_2

Elements per rod: 19

Heat ratings at 900°F sheath temp.: 49 W/cm

Heat ratings at 1300°F sheath temp.: 41·4 W/cm

Sheath outside diameter: 0·500 in. and 0·550 in.

Outside diameter of bundle: 3·00 in. and 3·500 in.

Nominal test section inlet temp.: 490°F to 600°F

Nominal test section inlet press.: 600 lb/in²a to 1500 lb/in²a.

The test section, which will replace the present 'X' rod configuration, consists of a zircaloy–2 pressure tube, operating at a temperature of approximately 300°F, internally insulated with compressed magnesium oxide totally enclosed in a liner.

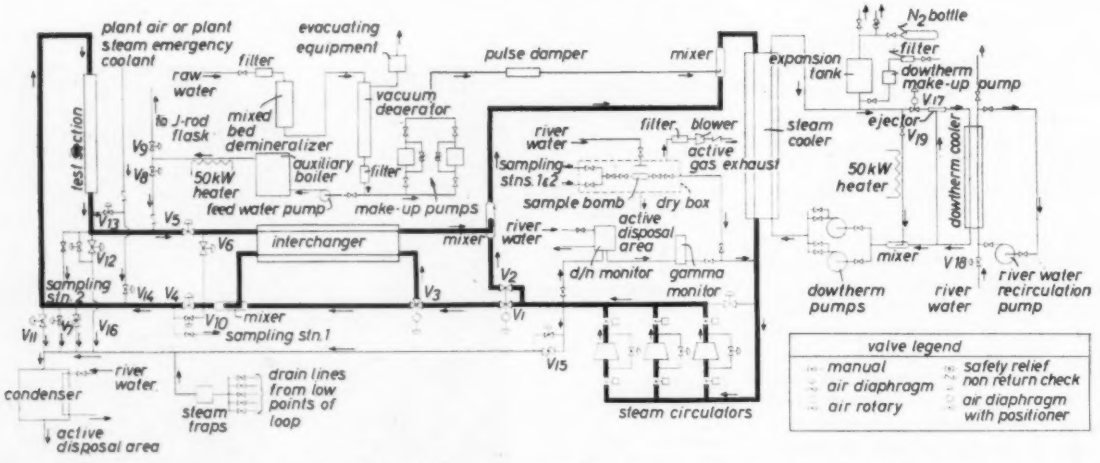
The steam is circulated by two independent single impeller centrifugal compressors operating in parallel and designed for a total flow of 20 lb/sec, at a pressure ratio of 1·18. A third compressor is installed as a stand-by. These units, mechanically designed for 1500 lb/in² 650°F outlet conditions, are operated within an imposed 600 h.p. limitation.

The shaft of each compressor is supported on water lubricated journal bearings in conjunction with a Kingsbury type thrust bearing. Ring seals, in combination with high pressure water, are employed for steam sealing. Leakage from the compressor seals and other loop components is passed through a condenser to the active disposal area. This lost steam is replenished by a continuous make-up which also acts to control the loop pressure.

The heat absorbed in the test section and compressor is removed by a secondary Dowtherm cooling circuit in order to keep thermal stresses at a manageable level. An inter-changer is used to raise the temperature of the steam at the compressor outlet to the desired test section inlet condition. Auxiliary circuits are provided for monitoring, gas sampling and decontamination.

The insulated zircaloy–2 pressure tube provides a nominal hole size of 3·5 inches and is designed for downward flow. The test section top closure incorporates leads, seals and contacts for six fuel element thermocouples, at the same time allowing removal of fuel, shields, etc., by use of the existing rod handling flask.

Overall control of the loop is achieved by individual control of the test section inlet and outlet temperature, the compressor inlet temperature and the system pressure. In the event of incidents such as a pipe failure, automatic emergency action consists of tripping the reactor, depressurizing the test section and introducing an external source of coolant.



Orenda Engine's superheated steam cooled loop design, using UO_2 fuel, is to be installed in Chalk River's NRU 200 MW heavy water reactor

Points from Papers

reports, meetings, conferences

850°C FISSION CHAMBER

The Zenith reactor has been designed to operate at core temperatures of 850°C and facilities have been provided so that the neutron flux distributions in the core can be monitored with the reactor at operating temperature. A new fission chamber meeting these requirements is described in report AEEW R26 'A fission chamber for operation at 850°C' by D. Barnes, R. C. Hollick, and F. Wade of the AEE, Winfrith.

Because of the facilities provided the largest outside diameter acceptable for the chamber is $\frac{1}{4}$ in. and due to lack of knowledge of lead-through seals the chamber was made at least 12 ft $9\frac{1}{2}$ in. long so that the terminating seal was in a position not subject to extremes of temperature. After tests the material chosen for constructing the tube was Nimonic 75 as it showed little increase in dimensions after high temperature cycling, the centre wire was also made of the same material to minimize differential expansion between it and the outer case.

Tests were also carried out on the effect of high temperatures on fissile coatings. Using nickel foils coated with uranium, flaking was observed with 2mg coatings, hardly any with 1mg, and none at all with 1·5mg. With platinum as the foil material the results were improved. Tests on a wide variety of insulating materials led to Degussit AL23 alumina being chosen as the preferred material. It is also necessary to keep the self capacity of the chamber down to the minimum; this is done by having as little insulating material in contact with the outer case and central wire as possible; the method of electrode support is shown in Fig. 1.

CORROSION IN THE VBWR

The low contamination level experienced to date in the Vallecitos BWR coolant system has enabled maintenance and modifications to be carried out without the need for chemical decontamination. This was stated in a paper 'Progress report—Corrosion and contamination in the Vallecitos Boiling Water Reactor' by D. W. Danielson, T. F. Evans, and G. G. Gaul read to the American Nuclear Society meeting at Chicago, last June.

The paper reports the work done on the corrosion rates of the steels used in boiling water reactor construction and were studied in out-of-pile boiling water environments and in the VBWR. Average corrosion rates of 12 mg/dm²/mo were obtained in 8000 h of testing 2¼%Cr–1% Mo steam piping. Pitting and other localized corrosion were minor. No unacceptable corrosion rates have been found in boiling water environments with the materials studied. The rates observed are consistent with the formation of a strongly protective, adherent oxide on the steel surface.

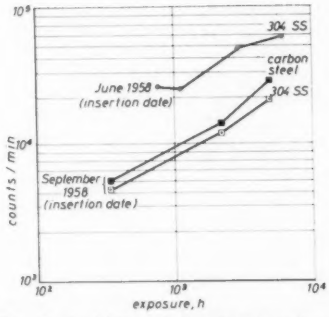


Fig. 2 Build-up of deposited radioactivity on the main steam line (5 days after shutdown)

Radioactivity deposited in the VBWR water and steam systems has been lower than originally anticipated (see Fig. 2). After 8000 h of operation, the turbine surface contamination gave dose rates of one to three mr/h at the surface. In spite of the fact the reactor was operated for extended periods with defected fuel in the core, activated corrosion products were the predominant radioisotopes in the surface deposits, both in the turbine and in the water and steam systems. At the present time, after two years of reactor operation, over half of the surface radioactivity is attributed to Co-60, at times as short as two days after reactor shutdown. Other long-lived radioisotopes present were Zn-65, Co-58, Cr-51 and Mn-54 (see Table 1). Contamination levels in the steam piping were a tenth to a hundredth of those in the water system and apparently increased with time at an unexpectedly slow rate.

Some tests were carried out to test the decontamination efficiency, for the VBWR system, of treatments developed at AEC sites for pressurized water reactor applications. It was found that two- and three-step treatments with alkaline permanganate and sodium acid sulphate, used successfully on pressurized water type systems, were ineffective on coupons removed from the VBWR coolant (decontamination factor about 2). A one-step sodium acid sulphate treatment with added fluorides proved to be effective. The results suggest a different type of scale forms in a boiling water reactor than in a pressurized water reactor. This difference is presumably a consequence of the different oxygen and hydrogen levels in the water in the two systems.

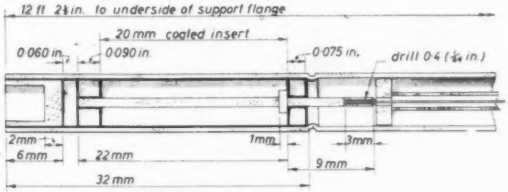


Fig. 1 Working end of high temperature fission chamber

TABLE 1 *Analysis of deposited radioactivity after 3700 hour exposure to reactor water (calculated to two days after shutdown)*

	μc/cm²	% GROSS GAMMA (OF LISTED NUCLIDES)
Co-60	0·54	69
Co-58	0·29	14
Zn-65	0·25	7
Mn-54	0·016	0·7
Cr-51	< 1·3	< 2
Fe-59	< 0·11	< 7
Sr-90	4×10^{-5}	0

Analysis was made three months after reactor shutdown

CONDENSER DOSIMETERS

A new report AERE M677 'The induced charge method of reading condenser dosimeters' by E. H. Cooke-Yarborough of AERE, Harwell, considers possible improvements to the pocket condenser chamber dosimeter which allows the dose to be read as often as is required without affecting the charge on the chamber.

GRAPHITE-CO_2 REACTION

A description of the various experimental techniques used in the study of the reaction between graphite and CO_2 and an appraisal of their various merits is given in report AERE M667 'Experimental techniques in the study of the reaction between carbon dioxide and graphite under radiation' by N. S. Corney, W. R. Marsh, and J. Wright, of AERE, Harwell.

New Reports

Methods of calculation for use in the design of shields for power reactors. A. F. Avery, D. E. Bendall, J. Butler, and K. T. Spinney. A.E.R.E. Harwell. *Report AERE R3216.* 187 pp. Available from HMSO 25*s*.

Results of the initial loading and low level testing program for the Dresden reactor. R. O. Brugge and E. Garelis. General Electric Company, Atomic Power Equipment Dept. 19 pp. Paper read to the American Nuclear Society. For copies apply to the authors or NUCLEAR POWER.

The market for nuclear equipment and instrumentation. Part III of the Stresa Conference 11-14 May 1959. 272 pp. Published by the Organisation for European Economic Cooperation, European Nuclear Energy Agency. Available from HMSO.

Fast breeder reactor program. USAEC July 1960. *Report TID-8532.* Available from OTS $0.50 or depository library.

Parametric study of a PuO_2-UO_2 fast oxide breeder. P. G. Aline, P. Greebler, and F. J. Leitz, General Electric Company, Atomic Power Equipment Dept. For copies apply to the authors or NUCLEAR POWER.

Fuel element temperature distribution and lifetime is determined by a statistical method

Predicting fuel element lifetime

by J. K. DAVIDSON and L. H. DEVLIN, Allis-Chalmers Mfg. Co.

CONVENTIONAL PROCEDURE in designing a reactor core is to choose a design fuel surface temperature that will virtually preclude fuel element failure, but a reactor design in which failed fuel elements may be located and replaced, removes the need for thus de-rating the performance. A more realistic design basis is to determine the distribution of fuel element temperatures, power and exposure, so that a probable number of failures can be estimated. The plant can then be operated at those conditions which result in fuel failure rates consistent with the fuel handling capability of the plant. The Experimental Gas Cooled Reactor (EGCR), under construction at the US Oak Ridge National Laboratory, has been designed for detection and removal of failed elements during operation, and is an ideal reactor for this type of analysis.

EGCR preliminary design

EGCR is a helium-cooled, graphite-moderated, 85-MWt reactor. The coolant inlet and outlet temperatures are 510°F and 1050°F, respectively. The fuel assembly designed for a lifetime of 10,000 MWd/t of uranium, is a cluster of seven stainless steel cans containing slightly enriched, cored UO_2 pellets. The cans are supported and positioned in a 29 in. long graphite sleeve by top and bottom spiders. The seven fuel elements, 0·75 in. o.d., are arranged in a hexagonal array within the 3 in. i.d. sleeve. Six fuel assemblies are vertically stacked in each of the 216 active fuel channels of the reactor core.

Fuel assemblies are loaded and unloaded from the bottom of the reactor during full power operation. Each fuel assembly will be relocated within its channel once during its lifetime for uniform burnup. During fuel loading, the bottom three assemblies in a channel at the final exposure are removed, the top three assemblies are moved in the bottom three positions, and fresh fuel assemblies are loaded in the vacant top three positions.

Determination of design temperatures

For analytical purposes, the core was divided into six zones by grouping channels of nearly equal thermal power into a zone. The core was further divided into vertical sections; this was conveniently represented by the six fuel assemblies in each channel. A radial neutron flux distribution and an axial flux distribution for the loading programme were calculated. The axial temperature profiles for the coolant gas and cladding were calculated on

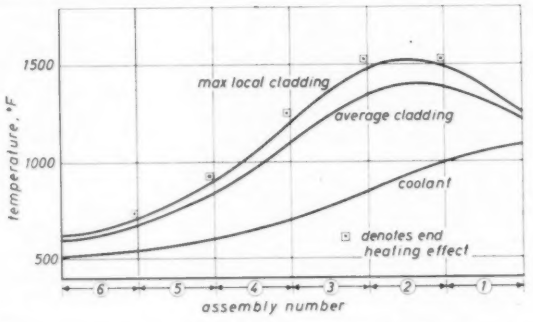


Fig. 1 Design temperatures — maximum power channel where power = 0·476 MWt and flow = 2330 lb/h

the basis of the appropriate axial flux distribution for the channel with the maximum power (Fig. 1).

Coolant and cladding temperature profiles are nearly identical for all channels in the core since the zones are orificed to give the same design fuel cladding temperature. The maximum *local* cladding temperature was calculated, accounting for such factors as axial and radial neutron flux gradients within an assembly due to self-shielding of the fuel, and variation in the peripheral heat transfer coefficients due to flow asymmetry associated with rod bundles in the channels.

The location of the maximum cladding temperature for each assembly in a channel was found and the coolant temperature rise and film temperature drop at that location were determined. These values gave the design temperature for each assembly. The distribution of temperatures caused by hot-channel factors was based on this value as a mean.

TABLE 1 *Design conditions in Zone 1*

ASSEMBLY NO.	T_s* °F	ΔT_c* °F	ΔT_f* °F	(q/L)Av Btu/h-ft	ΔT_g, °F	ΔT_f, °F	ΔT_g, °F	ΔT_{UO_2} °F	BURNUP, MWd/tonne
1	1480	480	500	15,050	530	270	226	705	3476
2	1525	480	545	25,900	410	470	389	1212	5276
3	1525	330	685	25,600	260	470	384	1200	6416
4	1250	190	540	17,200	130	310	258	805	10,000
5	925	90	325	9600	55	190	142	452	10,000
6	730	35	185	5250	20	95	78	246	10,000

T_s* (max) = maximum local cladding temperature, ΔT_c* = coolant temperature rise to the location of T_s* (max), ΔT_f* = film temperature drop at the location T_s* (max), (q/L)Av = heat rate per foot of length evaluated at the mid-point of the longitudinal axis, ΔT_c = coolant temperature rise to the mid-point of the longitudinal axis, ΔT_f = film temperature drop at the mid-point of the longitudinal axis, ΔT_g = temperature drop across the gap at the mid-point of the longitudinal axis, and ΔT_{UO_2} = temperature drop across the UO_2 at the mid-point of the longitudinal axis.

The temperature of the inner UO_2 surface averaged over the length of the assembly was determined in order to predict the internal gas temperature and, subsequently, the fission gas pressure. The surface temperature and the heat rate per unit length at the midpoint of the longitudinal axis for each assembly were used in calculating the average inner UO_2 temperature. Total temperature difference from the cladding to the inner boundary of the UO_2 is the sum of the temperature difference through the assumed 1-mil gap between the cladding and the UO_2 pellet and the difference through the UO_2.

Design values for each assembly in Zone 1 are listed in Table 1.

Determination of hot-channel factors

For this analysis, hot-channel factors represent variations from the nominal calculated temperature associated with uncertainties (local neutron flux values), dimensional tolerances (in fuel-element cladding diameter) or operating deviations (allowable band of coolant outlet temperatures). Hot channel factors must be identified and the magnitude of each factor must be estimated on the basis of a given confidence level. This is related to the probability that an event will fall outside specified limits. The wider the limits, the smaller the probability that they will be exceeded. The confidence level selected corresponds with a chance that one value in 385 will fall outside the limits or, conversely, that 384 events in 385 (or 99·74%) will fall within the limits. Selection of this confidence level was based on the probability for three standard deviations from the mean value for a normal distribution. The magnitude of an individual factor is obtained by estimating the 'maximum' error and assuming it to be at a 99·74% confidence level. The hot-channel factors considered are shown in Table 2.

Errors for each factor affecting the surface temperature can be combined to give an over-all error at the same confidence level for the distribution of temperatures about the design temperature. This final distribution is then assumed to be 'normal'; the standard deviation for the surface temperature (T_s^*) at a particular location in the channel is given by:

$$3\sigma T_s^* = \left[\sum_{i=1}^{n} ({}_iE_c \Delta T_c^* + {}_iE_f \Delta T_f^*)^2 \right]^{\frac{1}{2}}$$

where

σT_s^* = standard deviation about the nominal cladding, ${}_iE_c$ = error at 99·7% confidence level for the i^{th} factor applied to the coolant temperature rise, ΔT_c^* = coolant temperature rise to the location of T_s^*, ${}_iE_f$ = error at 99·7% confidence level for the i^{th} factor applied to the film temperature drop, and ΔT_f^* = film temperature rise at location T_s^*.

TABLE 2 *Hot-channel factors*

	FACTOR* coolant	film	gap	UO_2
1. *Channel coolant temp. measurement*	1·09			
2. *Coolant mixing within a channel*	1·05			
3. *Leakage between channel and annulus*	1·04	1·03		
4. *Fuel-channel power and flow*		1·105	1·175	1·175
5. *Heat-flux distribution within channel (edge and end effect)*		1·10	1·10	1·10
6. *Fuel concentration and density*		1·08	1·08	1·08
7. *Fuel element cladding dimensions*		1·015		
8. *Gap dimension*			2·00	
9. *Heat transfer coefficient*		1·30		
10. *Ratio of local-to-average heat transfer coeff.*		1·05		
11. *Gap conductivity*			1·30	
12. *UO_2 conductivity*				1·30

*Based on 99·7% confidence level.

Table 3 illustrates the combination of hot-channel factors to give the standard deviation of the cladding temperature distribution.

Similarly, the standard deviation for the UO_2 centre temperature distribution is found by the expression:

$$3\sigma T_u = \left[\sum_{i=1}^{n} ({}_iE_c \Delta T_c + {}_iE_f \Delta T_f + {}_iE_g \Delta T_g + {}_iE_u \Delta T_u)^2 \right]^{\frac{1}{2}}$$

where

${}_iE_c$ = error at 99·7% confidence level for the i^{th} factor applied to the coolant temperature rise, ΔT_c = coolant temperature rise to the mid-point of the longitudinal axis of the assembly, ${}_iE_f$ = error at 99·7% confidence level for the i^{th} factor applied to the film temperature drop, ΔT_f = film temperature drop at the mid-point of the longitudinal axis, ${}_iE_g$ = error at 99·7% confidence level for the i^{th} factor applied to the gap temperature drop, ΔT_g = gap temperature drop evaluated at the mid-point of the longitudinal axis, ${}_iE_u$ = error at 99·7% confidence level for the i^{th} factor applies to the UO_2 temperature drop, and, ΔT_u = temperature drop through UO_2 evaluated at the mid-point of the longitudinal axis. An example of this calculation is given in Table 4.

It should be noted that the Δt terms are evaluated at the mid-point of the longitudinal axis of the assembly to maintain consistency with the approximation of the average inner UO_2 temperature occuring at that point.

Prediction of internal gas pressure and cladding stress

The principal cause of fuel element failures is a combination of excessive cladding temperatures and internal gas pressure from build-up of gaseous fission products. The ceramic UO_2 fuel will retain a portion of the gaseous fission products in its crystalline lattice; the remainder will diffuse into the void volume within the fuel element. Other causes of failure, such as fabrication defects or inclusions in the cladding, are not considered since they

TABLE 3 *Cladding temperature variation due to hot-channel factors*

ZONE 1 ASSEMBLY 3 $\Delta T_c^* = 330°F$ $\Delta T_f^* = 685°F$

FACTOR NO.	${}_iE_c$	${}_iE_c\Delta T_c^*$	${}_iE_f$	${}_iE_f\Delta T_f^*$	$({}_iE_c\Delta T_c^* + {}_i\sigma_f\Delta T_f^*)$	$({}_iE_c\Delta T_c^* + {}_iE_f\Delta T_f^*)^2$
1	0·09	29·7			29·7	882
2	0·05	16·8			16·8	282
3	0·04	12·9	0·03	20·4	33·3	1520
4			0·105	72·0	72·0	5184
5			0·10	67·8	67·8	4597
6			0·08	55·5	55·5	3080
7			0·015	10·2	10·2	104
8						
9			0·30	205·0	205·0	42,025
10			0·05	34·8	34·8	1211
11						
12						

$$\sum_{i}^{12} ({}_iE_c\Delta T_c^* + {}_iE_f\Delta T_f^*)^2 = \overline{58{,}885}$$

$$\sigma T_s^* = 80{\cdot}8°F$$

TABLE 4 *Inner UO_2 temperature variation due to hot-channel factors*

ZONE 1 ASSEMBLY 3 $\Delta T_c(av) = 260°F$ $\Delta T_f(av) = 470°F$ $\Delta T_g(av) = 384°F$ $\Delta T_{UO_2}(av) = 1200°F$

FACTOR NO., i	${}_iE_c$	${}_iE_c\Delta T_c$	${}_iE_f$	${}_iE_f\Delta T_f$	${}_iE_g$	${}_iEg\Delta T_g$	${}_iE_{UO_2}$	${}_iE_{UO_2}\Delta T_{UO_2}$	$\Sigma_i E\Delta T$	$(\Sigma E\Delta T)^2$
1	0·09	23·4							23	529,529
2	0·05	13·0							13	169,169
3	0·04	10·4	0·03	14·1					24	576,576
4			0·105	49·3	0·175	67·3	0·175	210	327	106,929
5			0·10	47·0	0·10	38·4	0·10	120	205	42,025
6			0·08	37·6	0·08	30·7	0·08	96	164	26,896
7			0·015	7·0					7	49
8					1·00	384·0			384	147,456
9			0·30	141·0					141	19,881
10			0·05	23·5					23	529
11					0·30	115·2			115	13,225
12							0·30	360	360	129,600
										487,864

$\sum_1^{12}(\Sigma E\Delta T)^2$

$\sigma_{UO_2} = 232$

are independent of reactor performance and it is assumed that they can be controlled by inspection procedures.

Pressure of the internal gas in an element is the sum of the partial pressure of the helium sealed in during fabrication and the pressure of fission gas released by the UO_2. The internal pressure in a fuel element is given by:

$$p = 2{\cdot}33\,(10^{-5})\,B\,f\,(T_g + 460) + 14{\cdot}7\,\frac{(T_g + 460)}{68 + 460}$$

where

B = fuel burnup, MWd/t, f = fractional fission gas release, T_g = average temperature of internal gas, °F.

The temperature of the internal gas is assumed to equal the average inner UO_2 temperature for an element. It is assumed that the gaseous fission as iodine, bromine, and caesium, are neglected owing to their low concentrations and high chemical activity.

A value for the fractional fission gas release had to be assumed since experimental evidence is lacking for the range of UO_2 temperatures under consideration. The selected value, 0·50, was derived by a conservative extrapolation of data obtained by the Westinghouse Atomic Power Division in PWR experiments. The Oak Ridge National Laboratory is conducting an in-pile programme to determine experimentally the fission gas release under EGCR operating conditions.

The stress in the cladding is obtained from the expression for a hoop stress in a thin wall cylinder. Therefore, for a given surface temperature, the stress in the cladding can be related to burn-up and power per unit length.

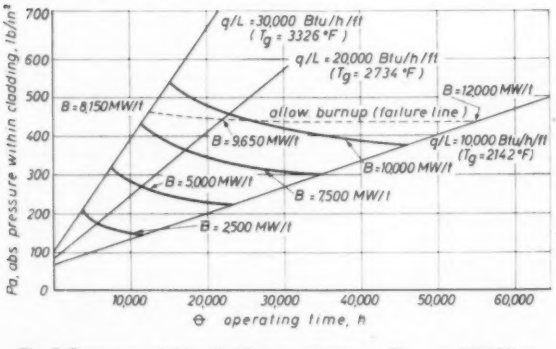


Fig. 2 Pressure within cladding vs. exposure. $T_{clad} = 1550°F = 2010°R$ $T_{gas} = T_{clad} = 0{\cdot}0592(q/L)$ Cladding sealed at 70°F 14·7 lb/in²a average coolant pressure = 310 lb/in²a. Steady state:— $T_{cl} = 1550°F$; $T_g = T_{cl} + 0{\cdot}0592(q/L)$

Determination of allowable stresses for fuel cladding

Allowable stresses in the cladding were determined on the basis of creep and stress-rupture data obtained in air for type 304 stainless steel. Creep data are not available at temperatures above 1500°F. Therefore, stress-rupture data were used for the higher temperatures. The differential pressure increases with time from an initial negative value, due to the external system pressure, 315 lb/in²a, to a positive value. Maximum allowable pressures for cladding temperatures above 1500°F were predicted by adding to the equalizing pressure (system pressure) an estimate of the additional pressure that can be expected without significantly straining the cladding; the estimate was based on stress-rupture data. The allowable pressures calculated were superimposed on the plots of pressure against burnup and power per unit length to define the combination of conditions that will cause failure (see Fig. 2) Since *failure* pressure is nearly independent of the time required to reach that pressure, the failure pressure can be plotted against local cladding temperature (Fig. 3).

Probability of failures for a particular region

To obtain the number of fuel element failures, the results of the three previous studies were then combined: the nominal design temperatures, the standard deviation

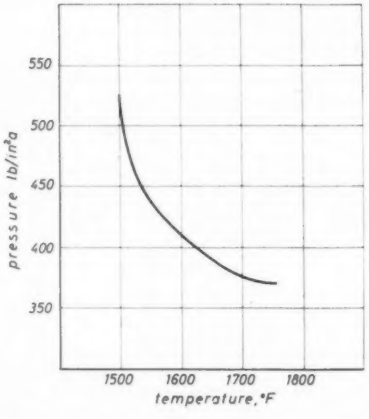


Fig. 3. Internal failure pressure vs. local cladding temperature

TABLE 5 *Probability of an element failure in an assembly*

ZONE 1 ASSEMBLY 3 DESIGN $T_s^* = 1525°F$ $\Delta T_g + \Delta T_{UO_2} = 1584°F$ $C_1 = 1525 - 1240 = 285°F$ $B = 6416$ MWd/t

TEMP RANGE OF T_s^*	PROB.	$T_s = T_s^* - C_1$	T_G	σT_G	INTERNAL PRESS., p	σ PRESS.	FAILURE PRESS, p_f	PROB. OF $p > p_f$	PROB. OF FAILURE
1500–1550	0·243	1240	2824	232	336	22	465	0	0
1550–1600	0·203	1290	2874	232	340	22	422	0	0
1600–1650	0·117	1340	2924	232	346	22	398	0·009	0·001
1650–1700	0·044	1390	2974	232	350	22	380	0·087	0·004
1700–1750	0·012	1440	3024	232	355	22	372	0·221	0·003
1750–1800	0·003	1490	3074	232	360	22	370	0·326	0·001
								PROB.	0·009

$\sigma T_s^* = 80·8°F$
$\sigma T_{UO_2} = 232°F$

for the distribution of temperatures about the nominal design temperatures, and the failure criteria.

To determine the probability that a temperature will be within a given range, the frequency distribution of temperatures about the mean value must be known. The combination of factors was assumed to cause a normal temperature distribution. The probability that a temperature will lie within a given range is the integral of the distribution curve (between the upper and lower limits). Values for the integral of the normal distribution are given in tables of the error function. A table was prepared for each assembly, giving various temperature ranges (1500° to 1550°, 1550° to 1600°, etc.); the probability that a cladding temperature would lie within a particular range was obtained from a table of the error function. The second column of Table 5 presents the temperature probabilities for Assembly 3, Zone 1.

The distribution of the cladding temperatures was based on the maximum nominal temperatures for each assembly in a given zone. This procedure was repeated for the other five assemblies in the channel.

In calculating local cladding temperatures, peripheral variations in the heat transfer coefficient and heat flux must be accounted for. Since the inner UO_2 temperature is to be based on a cladding temperature averaged over the length, the local temperatures are corrected to obtain an average value for each temperature interval.

Burnup for a specific assembly was assumed to be at its maximum value for that particular position. The internal gas pressure, a function of gas temperature and burnup, is obtained from the formula quoted above. This value represents the pressure in the elements when they are to be relocated (either discharged or moved into the bottom three positions) and is therefore the maximum pressure for any element in a given channel position.

For this nominal internal pressure, there is a distribution of pressures about the mean value, owing to the distribution of inner UO_2 temperatures resulting from hot-channel factors. The standard deviation of the pressure distribution is directly related to the standard deviation for the inner UO_2 temperature distribution. The internal pressure sufficient to cause the cladding to fail for a given cladding temperature range is obtained from Fig. 3. The probability that the internal pressure will be equal to or greater than the failure pressure is given by

$$\text{Prob}\,(p \geq p_f) = 1 - \frac{p_f - p_m}{\sigma \text{ press.}}$$

where

p_m = mean value of pressure distribution, lb/in²; p_f = failure pressure, lb/in²; σ press = standard deviation of the pressure distribution, lb/in².

The probability of failure is then the product of the probability that the surface temperature will be in a given range and the probability that the failure pressure will be exceeded. The sum of the failure probabilities for each temperature range equals the total probability that an assembly will fail. Table 5 presents the failure probability for Assembly 3, Zone 1. These calculations are repeated for each assembly in a zone and for each zone in the core.

Evaluation of the number of failures

The final step in the analysis is the prediction of the number of failures in each zone.

The number of assemblies that will fail in a particular zone is determined by summing the failure probabilities for the six assemblies in a channel and multiplying by the total number of elements in the zone. The total number of failures in the reactor is the sum of the predicted failures in each zone.

Under EGCR design conditions, five fuel assemblies in a core loading of 1296 assemblies will contain a failure before the design exposure of 10,000 MWd/t of uranium is reached. The percentage of fuel assemblies with maximum local cladding temperatures operating within various temperature ranges are:

Cladding temperature, °F	%
Less than 1500	72
1500–1600	22
1600–1700	5
Greater than 1700	1

Acknowledgments

The authors acknowledge the contributions of the members of the Experimental Gas Cooled Reactor Project in the development of this analysis, particularly G. Karp and L. Kintner, who defined the hot-channel factors, and H. Sturza and G. Longanecker, who assisted in defining the fuel element failure criterion. This article is based on studies conducted for the US Atomic Energy Commission under contract AT(10-1)-925. Portions of this article were presented at American Nuclear Society meeting; Washington, D.C., November 4–6, 1959.

References

1. Bonilla, F., ' Nuclear Engineering ', McGraw-Hill, 1957.
2. Thrasher, L. W., and Binder, R. C., *Trans. ASME*, Feb. 1957.
3. Buckley, P. S., *Chem. Eng.*, Sept. 1950.
4. Le Tourneau, B. W., and Grimble, R. E., *Nuclear Science and Engineering*, Oct. 1956.

The changes in mechanical properties created by displaced atoms and vacancies through fast neutron bombardment are discussed

Radiation effects in cladding materials

by R. S. BARNES, M.Sc., F.Inst.P., AERE, Harwell

MANY OF THE EFFECTS caused by radiation are due to the behaviour of 'point defects'. Other effects are caused by foreign atoms introduced into the crystal by the radiation, e.g., neutrons may cause some of the original atoms of the crystal to transmute, or the initial particle might come to rest, becoming a foreign atom itself.

Atomic displacement effects

In the last few years our understanding of the behaviour of point defects has improved, partially as a result of detailed observation of clusters in metal films, only a few thousand Angstroms thick, at high magnification in the electron microscope.

Metals near their melting point contain in dynamic equilibrium $\sim 10^{-4}$ vacancies to each atom, the number decreasing very steeply with temperature. If a metal is rapidly cooled (quenched) there is not time for the excess vacancies to escape to sinks in the material, e.g. grain boundaries and dislocation lines, and they cluster together to form flat plates which collapse to form dislocation loops (*1*). Vacancies which are near to the existing dislocation lines during the quench precipitate upon them and cause them to 'climb' into violent contortions. Grain boundaries also collect large numbers of the vacancies, but naturally they are little distorted by the process. Near these sinks there is a zone containing very few loops as a result of this loss of vacancies.

The loops are stable until the metal is heated to about half its melting temperature expressed in degrees Absolute ($Tm/2$), when appreciable numbers of vacancies are generated at the loops and diffuse. The large loops grow at the expense of the smaller, and during this process more of the vacancies are captured at the previously existing dislocation lines and grain boundaries. Eventually all the loops disappear when the material regains its former structure and properties.

The effects observed in irradiated materials resemble these and Fig. 1 shows much smaller dislocation loops in copper which has been bombarded with $\sim 10^{17}$ alpha-particles cm^{-2}, while at about 100°C. Neutron bombardment produces similar effects. The loops have clearly been formed by the agglomeration of the point defects produced during the bombardment, but in addition to vacancies, an equal number of interstitial atoms must have been produced. There is a marked similarity in the effects produced by these loops and loops produced by quenching, and their anneal temperature is the same.

The properties of the material are markedly altered by such a large number of local disturbances ($\sim 10^{15}\,cm^{-3}$). The mechanical properties which are so important in a cladding material are normally altered. The internal friction of copper which has received very small neutron doses ($\sim 10^{15}$ nvt) is very much reduced in the kilocycle range (*2*). Gamma radiation and quenching produce similar effects as shown in Fig. 2. The oscillation of dislocation lines in their slip planes is the main cause of the internal friction and the gross distortions of the dislocation lines caused by the irradiation understandably restrict this oscillation, reducing the internal friction such that the copper rings like a bell.

The initial movement of a dislocation is thus more difficult in an irradiated material and this is reflected in its stress/strain curve. The elastic limit is much extended and usually a small yield drop occurs when eventually dislocations do break through. The yield stress can be so much

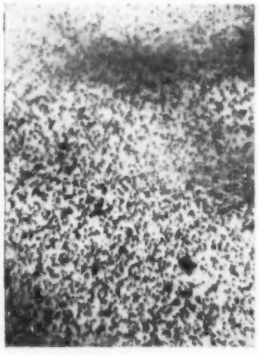


Fig. 1. Dislocation loops in copper bombarded with 10^{17} alpha-particles cm^{-2} while at 100°C. ×40,000

increased that very little work hardening takes place when slip occurs. Then, if the material is in tension, yield continues where it has started with immediate necking down and no uniform elongation. This happens with irradiated niobium (*3*). In this material the effects are more pronounced after an ageing treatment at 200°C when it is thought extra vacancies diffuse both to the dislocation lines (further contorting them) and to clusters. As a cladding material must normally deform a little during service, this localization of deformation as a result of irradiation can limit the use of the material.

It is known that the small loops such as those seen in Fig. 1 impede the flow of the dislocations, and in material susceptible to brittle fracture, irradiation can cause an increase in the transition temperature because a crack has a better chance to form and grow.

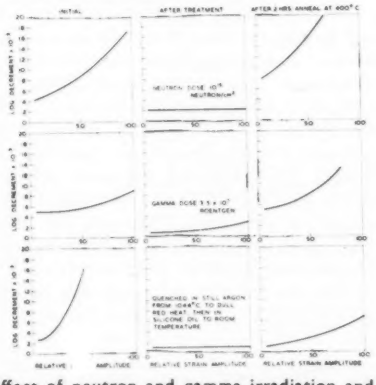


Fig. 2 Effect of neutron and gamma irradiation and quenching on the internal friction of polycrystalline copper rods. A relative strain amplitude of 100 ≃ strain amplitude 4×10^{-8} (*2*)

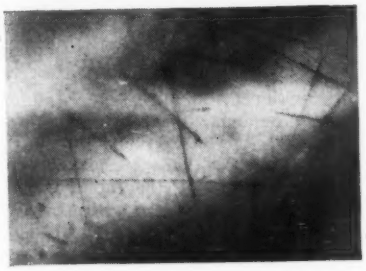


Fig. 3 Tracks of fission fragments near the surface of mica irradiated for 5 minutes in BEPO close to a layer of uranium (*5*). ×40,000

The effects due to atomic displacements can be detected at low doses (~ 10^{17} nvt) and become more pronounced but appear to saturate at high doses being proportional to $[1 - \exp(-B\phi)]^{\frac{1}{2}}$ (where B is a constant and ϕ the dose (*4*)), and not proportional to $\phi^{\frac{1}{2}}$ as was first thought. The nuclear or physical deterioration of the fuel imposes a limit to the time the fuel element can remain in the reactor (~10^{21} nvt) so the irradiation stability demanded of cladding materials is not as complete as that demanded of some other structural materials, but as the effects are caused predominantly by fast neutrons, the proximity of the cladding material to the fuel puts it in the most vulnerable position.

Of course if the cladding material is irradiated at a temperature greater than that at which the loops anneal (i.e. ~ $Tm/2$) the loops do not form and these effects do not occur. Then the material, if it is a pure one, is relatively immune to displacement damage. This is the situation in which many cladding materials are used. Effects are most likely in high melting point materials or in materials operating at relatively low temperatures, e.g. in water-cooled reactors.

Foreign atom effects

The capture of neutrons by some cladding materials causes transmutation with the internal formation of chemically new atoms. Beryllium is a notable example, in which fast neutrons produce helium. These foreign atoms modify the properties of the cladding material, and of course their effects are permanent.

However, it is not only this small class of materials which suffer from the build up of foreign atoms; all cladding materials which are in direct contact with the fuel material will be impregnated with fission products on their inner side. These can penetrate about 5 μ of the cladding material before coming to rest within it, and unless the temperature is sufficient for diffusion to occur it is only this inner layer which becomes contaminated. The fission fragments which are heavily ionized produce intense damage during their travel. This is illustrated in Fig. 3 which shows tracks left by the passage of uranium fission fragments through thin sheets of mica which were viewed in transmission in the electron microscope (*5*). The effect is very local (within about 100Å) to the long straight tracks. Occasionally the track deviates due to a direct collision with an atom of the mica and the track of the ejected atom can be seen. A cladding material will thus have more atoms displaced in this layer next to the fuel which will also contain these products in a concentration up to half that in the fuel itself.

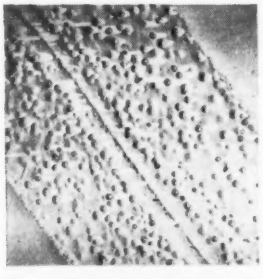


Fig. 4 Shadowed replica of helium bubbles near a grain boundary in copper (*7*). ×5000

Fig. 5 Helium bubbles seen in a thin film of aluminium ×5000

The inert gases xenon, krypton and helium form an important class of foreign atoms as they precipitate as bubbles at high temperatures. These bubbles grow by acquiring vacancies and not by plasticly deforming the material surrounding them (*6*), and thus in material containing the inert gas atoms, bubbles form first wherever vacancies can be generated. Fig. 4 shows the bubbles which have formed only near to the grain boundary. Dislocation lines which might be expected to contribute large numbers of vacancies do not do so because the helium atoms lock them preventing their motion either by slip or climb. However, when the vacancies have been supplied from the nearest sources the bubbles nucleate upon the dislocation lines and Fig. 4 shows the bubble patterns which are formed. The bubbles make the metal film more transparent to the electrons in the electron microscope and produce an image like an X-radiograph. However, the magnification is much higher and the strain fields due to the dislocation are also visible in the grain on the left of the figure. Long rows of bubbles can be seen and where the dislocation is visible the bubbles can be seen to lie upon them.

These bubbles are very effective in locking the dislocation, and only when the stress (σ) exceeds Gb/l (where G is the shear modulus, b the Burgers vector of the dislocation line and l the spacing of the two locking bubbles in question) can the dislocations bow out and break away from the locks. The small bubbles thus harden the material.

Further heating coarsens the bubbles by a process not yet fully understood and the bubbles become fewer and larger. The distance l then increases and the hardening effect of the bubbles is diminished. However, because the pressure (P) of gas within these small bubbles (radius r) is balanced almost entirely by the surface energy (γ) ($P = 2\gamma/r$) the gas pressure diminishes as the bubbles coarsen and the total volume of the bubbles becomes larger. Whereas, the volume occupied by the gas when it is in bubbles radius ~ 100Å is negligible, when they are ~ 10^{-4} cm the volume occupied, and thus the volume increase of the material is appreciable. It has been shown (*8*) how the number of bubbles vary with their radius where it can be seen that Nr^3 = constant, suggesting that the gas obeys the perfect gas laws and that its pressure is in fact determined solely by the surface energy.

This increase in volume can be greatly accentuated by moving grain boundaries which can sweep the gas into larger bubbles. In material containing gas it is thus essential to avoid grain growth. The bubbles themselves prevent this by locking the grain boundary, but if the driving force is large enough the grain boundary can break away and these large bubbles will form. In extreme cases this could cause the boundary to become permeable.

Acknowledgment

Figures 3 and 4 by courtesy of *The Philosophical Magazine*.

References

1. Hirsch, P. B., *et al.*, *Phil Mag.*, **3**, 897, (1958).
2. Barnes, R. S., et al, *Phil. Mag.*, **3**, 519, (1958).
3. Makin, M. J., and Minter, F. J., *Acta Met.*, **7**, 361, (1959).
4. Whapham, A. D., and Makin, M. J., *Phil. Mag.*, **5**, 237, (1960).
5. Silk, E. C. H., and Barnes, R. S., *Phil. Mag.*, **4**, 970, (1959).
6. Barnes, R. S., et al, *Phil. Mag.*, **3**, 97, (1958).
7. Barnes, R. S., *Phil. Mag.* to be published.
8. Barnes, R. S., AIMMPE special report 9, *Nuclear Metallurgy* **6**, 21–4, (1960).

Cross Section by GRACCHUS

RANDOM SPECULATION about the cost per kilowatt sent out for Dungeness, ranging from a surprising low of £98 (happily avoided, I note, by this journal) to a high of £120, has been cut short by Sir Christopher Hinton. His happy mean is £110/kW, the figure he gave in his lecture 'The Evolution of Nuclear Power Plant Design' at the Royal Society's Tercentenary Celebrations. I was tempted to ask why this information could not have been given at the time of the Dungeness contract announcement; however, I decided to resist this move and remain thankful for small mercies when I remembered that Mr. Robert McKinney's recent report on US nuclear policy overseas is considered so 'secret' that only one copy is being circulated among members of the US Joint Congressional Committee on Atomic Energy.

Sir Christopher's lecture, however, was only one aspect of the Royal Society's celebrations. The Albert Hall, the right place for the opening ceremony; delegates in full academic regalia; the presence of the Queen; concerted blasts from trumpets; clashing of cymbals and an organ, more reminiscent of Berlioz than Brahms, thundering through 'Gaudeamus', must have satisfied every lover of pomp and ceremony. Later in the month came the conferring of honorary degrees and the pleasing ovation given to Professor Nikolai Semenov, director of the Moscow Institute of Chemical Physics, at Oxford when he received the honorary degree of Doctor of Science—an honour also bestowed on Professor Felix Bloch, director general of the European Centre of Nuclear Research.

DISCUSSIONS on the successor body to the Organization for European Economic Cooperation in Paris have tended to overshadow one of its specialized agencies—the European Nuclear Energy Agency. This body, in contrast to the more publicized and political Euratom, has some solid accomplishment behind it: the Halden project, Eurochemic and Dragon are well-known international projects. The next move by ENEA, I understand, is to be the organizing of an international effort on marine propulsion. If successful, ENEA's project should result in a welcome tidying-up and channelling of various national efforts in Europe.

THE FUTURE NEED for low cost power from small reactors, which is receiving such close attention in the United States, was again commented upon recently by the Chairman of the USAEC, Mr. John McCone. In his talk to the American Public Power Association Convention, he based this programme on two points: meeting the needs of large numbers of consumers, and as an instrument of foreign policy. This is in some contrast to our own policy towards small reactors which is hardly one of definite encouragement. But there is always the exception, of course, and I understand that at the moment, the Authority and the General Electric Company are having discussions on a small advanced gas-cooled reactor design study that the GEC is carrying out for Portugal. This started some months ago as the project is essentially a long term one. The reactor itself is the type developed within the GEC/Simon-Carves Group and uses uranium-dioxide fuel.

THE LONG-AWAITED McKinney report on US nuclear policy abroad, now before members of the Joint Congressional Committee on Atomic Energy, while it hardly allays fears by European officials is, I understand, less scathing than expected. I believe that it does not say there should be an immediate stop to the building of Euratom nuclear stations; but it does recommend that the major effort should be directed towards a research and development programme aimed at developing economic nuclear power.

It is also critical of the 'Atoms for Peace' programme and recommends that the US join with other research establishments in America and Europe in a programme to extend the frontiers of nuclear technology. My own opinion is that if this recommendation were to be carried out, the future Organization for Economic Cooperation and Development, the successor to OEEC, will play a large part and that the European Nuclear Energy Agency may well take a leading role in these moves.

THE SECOND REPORT of the Committee of Public Accounts contains some interesting information on what it describes as a ten year A.E.A. contract, 'placed in 1952, for the supply of a certain chemical.' A new contract was negotiated to run for five years from January 1959 to provide for an increase in requirements. Under this, the whole cost of the additional plant amounting to £309,500, is recovered over the period of the contract and the manufacturer receives an assured minimum annual profit.

Apparently the AEA had not discussed what the terms would have been if the Authority provided the capital for the additional plant. But they doubted whether better terms could have been negotiated. Moreover, the price demanded by a foreign alternative source was more than double that which they were paying under this contract.

The Committee gently tells the AEA that they should have discussed what these terms would have been. In similar circumstances, where the terms of a proposed contract involve payment of high rates of amortization and profit on capital, the Committee says the AEA, in consultation with the Treasury, should reconsider their practice of not advancing capital to contractors who are in a position to advance it themselves.

ONE RESULT of the stretching out of Britain's nuclear power programme may be a fall in the price of the uranium that the AEA is selling to customers. Interest on the capital invested in the stocks of uranium held by the AEA, Parliament was told shortly before its summer recess, would probably run to several million pounds annually and stocks would last for about ten years. With future demand from the Generating Board likely to fall by some 40% as a result of the revision of the nuclear power programme and the comparatively low prices ruling elsewhere, the AEA will have to look again at its own charges.

New Product Survey

EQUIPMENT · INSTRUMENTS · MATERIALS

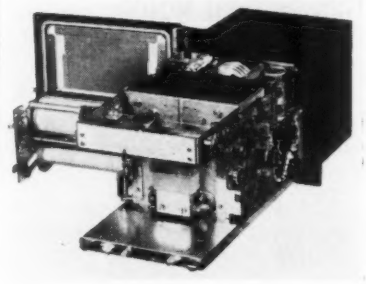
★ For further information on any item, circle the appropriate number on the reply card facing page 162.

TEMPERATURE MEASUREMENT

multi-trace recorder

The 4-in. high speed potentiometric recorder of AEI is basically an instrument for thermocouple temperature measurement, with range changing by plug-in card. It is suitable for a 6-in. square panel cut-out and is available in single trace and multi-trace versions.

It is fitted with automatic cold junction compensation, and is capable of accepting d.c. signals from thermocouples, resistance thermometers, strain gauges, telemetering instruments and pH-measuring equipment. The recorder is a continuously self-balancing instrument capable of accepting signals from all patterns of thermocouples, etc., over millivolt ranges of 0–1 mV to 0–200 mV.



This AEI recorder is based on a d.c. potentiometer and uses a 4-in. chart which is traversed in 3 seconds

★ No 208

RADIATION MONITORS

cadmium sulphide photocells

Photoconductive cells employing single cadmium sulphide crystals have been developed by AEI that respond to X- and gamma-rays.

Two types of cell are produced. Type V.021 is an intracavitary cell suitable for medical use or other applications where very small size is essential. It is so small that it can be swallowed by or inserted into a patient and used to measure the gamma-ray absorption of tissue and organs—an important factor in the therapeutic use of radiation. Type V.022 is a standard cell suitable, if used in large numbers, for continuous monitoring of gamma-ray flux over a large area.

Both cells have a linear response to voltage and may be used under a.c. or d.c. conditions up to 100 V peak. They may pass up to one mA when supplied with 100 V d.c. and irradiated with gamma-rays at 1 r/min. Cells are individually calibrated against a cobalt-60 source giving a flux at the crystal of 1 r/min.

The V.021 sensitive element is a single cadmium sulphide crystal mounted axially in a thin-walled glass tube. The crystal is very close to one end of the tube to facilitate use as a probe. One terminal is a Dumet wire sealed into the glass, the other a silver cap. The unit is vacuum sealed for stability. Overall length, excluding wire, is 14 mm ±2 mm, with overall diameter not greater than 1·7 mm.

The V.022 sensitive element is a cadmium sulphide crystal mounted horizontally on a header and hermetically sealed under a glass dome. Length (excluding wire) is 6 mm, diameter is 6 mm.

★ No 209

URANIUM ANALYSIS

spectroscopic method

A method of analysing the three major uranium isotopes by emission spectroscopy has been developed by Baird-Atomic. The new instrument is a modification of the direct reading optical emission spectrometer and makes possible quick and convenient analysis of both enriched and depleted samples, with an accuracy comparable to mass spectrometer methods.

The instrument uses the automatic optical servo monitor of the standard direct reading spectrometer in combination with a special diffraction grating and a three-prism beam-splitter.

The grating gives a dispersion of 0·8 A per millimeter and a special beam-splitter, consisting of three glass prisms, gives additional separation to the extremely close spectrum lines of the isotopes.

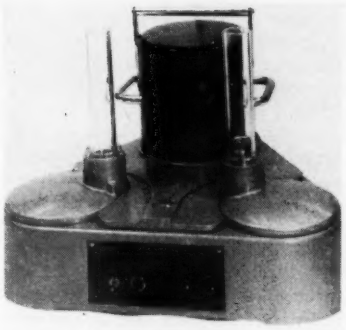
★ No 210

RADIOACTIVE SAMPLING

automatic changer

Labgear's automatic radioactive sample changer D.4137 has been designed so that the count obtained from a given sample shall be materially unaffected by the presence of other samples.

The apparatus comprises an alloy base-casting carrying a perspex turntable rotating beneath two sample-store tubes and a lead-castle housing a detector. The right-hand sample-store tube carries a vertical stack of the planchets to be counted which are gravity fed to a recess in the turntable for transfer to the counting position. The left-hand sample-store tube receives the samples after counting. Stacking here is accomplished by the aid of a ramp profile in the upper surface of the turntable. Hence, all samples, whether counted or to be counted, are at the same distance from the detector and thus contribute a sensibly constant background due to their proximity. In order to ensure the lowest possible background due to all sources, the detector is heavily shielded with lead, and for the purpose of counting, the sample is mechanically elevated from the turntable into the lead castle.



Employing an equilateral triangular geometry, Labgear's sample changer overcomes the problem count interference from other samples

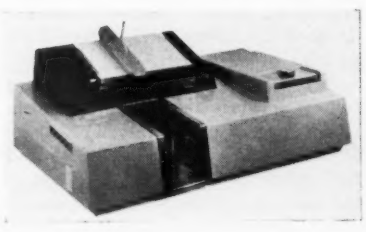
The sample changing sequence, once initiated by the momentary closure of two contacts, is entirely automatic. Time-controlled-counting and count-controlled-timing is possible with the use of ancillary equipment.

★ No 211

INFRA-RED SPECTROPHOTOMETER

controls simplified

The S.P.200 infra-red spectrophotometer, introduced recently, by Unicam is a simple and inexpensive double-beam instrument designed for routine analysis. The dispersing element is a rocksalt prism, and the complete range of the in-



Unicam's new spectrophotometer was on show at the recent Moscow Instruments Exhibition

strument, 650 cm^{-1}–5000 cm^{-1} (15·4μ–2μ), is covered in a single 10 minute scan. The source is a large, air cooled, Nernst filament.

The photometer is of the null type, and uses an optical wedge to give a linear transmission scale. The slits are programmed to give a constant energy background, the level of which can be adjusted, and are driven by a lever and cam mechanism. The instrument records percentage transmission via a linear wavenumber scale, using a flat-bed recorder. Overall chart size is 32·5 cm × 20·4 cm, and ruled area 28 cm × 15 cm. The instrument is simple to operate and particular care has been taken to keep the operating controls to a minimum. The sample compartment is open at the top and front for ease of access.

★ No 212

HIGH VOLTAGE RATEMETER

rapid response

A new ratemeter from Tracerlab is provided with a choice of nine scale ranges, from 0 to 100 counts/min to one million counts/min. Intermediate ranges are multiples of 3 and 10, thus permitting flexibility in selecting the optimum range for application. A total of eight different time constants are provided. On ranges up to 100,000 counts/min, selectable time constants are 0·5, 2·5, 10 and 40 seconds, whilst on the 300,000 and 1,000,000 counts/min ranges, the selectable time constants are 0·05, 0·25, 1·0 and 4 seconds.

The high voltage power supply has a high degree of regulation insuring that output voltage will change less than 0·003% for a 1% change in input voltage.

A 4½ in. meter provides direct indication of count rate or applied high voltage and is colour coded (red, green and black) to identify the scale being employed. The meter can be read to ± 3% of full scale and used with a strip chart recorder, accuracy is better than ± ½%.

★ No 213

SHORT WAVE RADIATION

portable detector

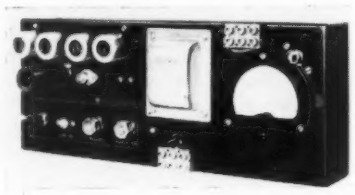
The Ramcor Model 1200 Densiometer is a portable, battery operated instrument, designed to detect and measure the amounts of VHF, UHF and microwave energy radiating from high power transmitters, antennas and related equipment. Unsafe areas around such equipment can be detected and mapped. A direct reading, red-green scale indicates instantly the presence of radiated energy above or below the presently accepted safe level of 10 mW/cm^2, as well as the intensity of this energy with respect to that level.

The instrument covers a range of 200 to 100,000 mc, and measurement in any desired band is accomplished by simply changing to the appropriate antenna, supplied with the instrument. ★ No 214

LEVEL INDICATOR

continuous reading

A new electronic level indicator has been developed by Thomas Industrial Automation. The 'Levolog' is basically a capacitance bridge which derives its energy from a stable single valve oscil-



Unicam's 'Levolog' is an electronic indicator simplified for plant operation

lator. The power supplies to the oscillator are stabilized by conventional methods and the bridge unit is split into two halves. One half feeds the electrode system, and the other the resistive capacitive balance net-work.

When this instrument is used in conjunction with the dual flexible electrode systems, a high degree of electrical stability is maintained in the electrode itself by an Araldite moulding process in the electrode head and by commoning the two active elements of the electrode close together in a plastic sheath.

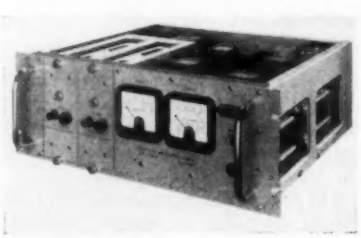
Using the dielectric constant of the material itself to complete the capacitive path between the two halves of the electrode, any incremental change of capacitance on the electrode produces an out-of-balance voltage in the bridge. This voltage is rectified by crystal diodes and fed via a suitable calibrating net-work to the indicating instruments which, in this particular instrument, have a sensitivity of 1 mA d.c. F.S.D.

★ No 215

COMPUTER POWER SUPPLY

stable voltage source

Solartron's Computer Reference Power Supply, Type AS 756.2, is now generally available as an independent instrument. Two independent positive and negative outputs are provided, + 100 V and − 100 V, each capable of being loaded up to 200 mA.



Solartron's reference power supply will remain within 5 mV and has a stabilization ratio better than 1000 to 1

The Reference Power Supply comprises two high-stability power supply sub-units with drift-corrected feedback control, using a Weston cadmium-mercury cell as a basic reference. The feedback control operates by comparing the output of the Weston cell against a fraction of the negative supply, any error voltage being amplified and applied as a correcting signal to the stabilizing control valve of the negative supply sub-unit.

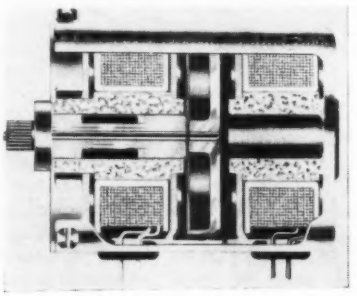
The positive output is then stabilized by reference to the 'corrected' negative supply, via a summing network and a second drift-corrected amplifier. The dimensions are 19 in. × 17 in. × 7 in. high and the weight is 55 lb.

★ No 216

SUBMINIATURE MOTOR

instantaneous starting

A subminiature motor, measuring 1$\frac{7}{32}$ in. long and weighing only two ounces, has been developed by Haydons. Featuring almost instantaneous starting and stopping characteristics, this unidirectional or



Cut-away version of the Haydon two-ounce motor

reversible 400-cycle a.c. timing motor, designated as the 25100 series, incorporates a phase-shift network, providing one winding ninety degrees out of phase to assure rapid starting, smooth operation, and ease of reversal.

With a diameter of only 0 947 in., the motors are ideal for applications where space is at a premium, while at the same time they are unaffected by extreme shock and vibration or temperature ranges from − 54°C to + 85°C.

Voltage is rated at 115 V, while current is specified at 20 mA. Power input is 3 W, with a torque rating of 0·01 oz-in. at 3000 rev/min starting and running.

★ No 217

BeO CERAMIC BODIES

industrial applications

Pure beryllium oxide ceramic bodies, fabricated in crucibles, rods, tubes,

vacuum tube envelopes, heat sinks, reactor moderators and many other shapes, are now available from the National Beryllia Corporation.

With a melting point of 2570°C, boiling point at 4000°C, a linear coefficient of $12{\cdot}1 \times 10^{-6}$ at 800–1000°C, a tensile strength of 3800 lb/in², and other excellent refractory properties, hard-fired BeO lends itself well to work at elevated temperatures.

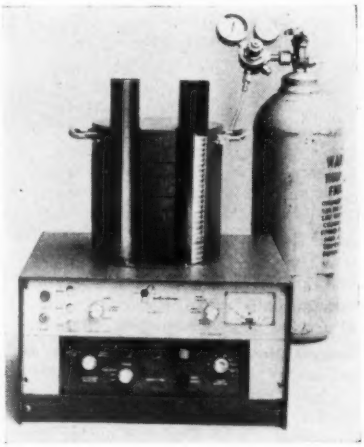
★ **No 218**

SAMPLE CHANGER

automatic counting

A new automatic counting system for beta emitting solid radioactive samples has been announced by Nuclear-Chicago. Background radiation is only 2 counts per minute, as contrasted with a normal background of 15–20 counts per minute in conventional systems of this type.

This low background makes possible the automatic analysis of radioactive samples having extremely low radio-



Nuclear-Chicago's C115 sample changer handles up to 35 radioactive samples automatically

active content (2–3 counts per minute). Analysis time can, therefore, be reduced significantly in routine sample measurements.

As an automatic system, it is of particular use in analysing milk and other substances for trace quantities of strontium-90, and for analysing samples containing carbon-14, phosphorus-32, sulphur-35, and other beta emitting isotopes.

The system will automatically handle up to 35 radioactive samples. The time required for each sample to reach a selected preset count is recorded automatically by a printing timer, together with the sample identification number. The entire system can be left unattended for a day or so and the printed data collected when convenient.

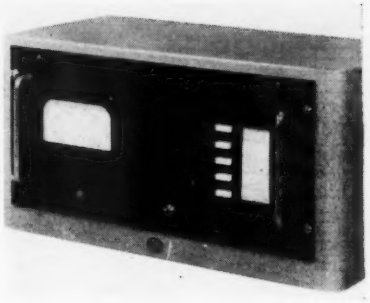
★ **No 219**

PULSE ANALYSER

scintillation counting

A single channel scanning analyser, designed by Labgear, comprises a wide band input amplifier followed by two fast discriminators. The lower threshold level is adjustable by means of a potentiometer which may be operated manually or, for continuous scanning, by a synchronous motor. When functioning as a discriminator an output pulse is obtained if the signal exceeds the chosen setting of the threshold level. When used as an analyser an output is achieved when the lower discriminator only is triggered.

The mirror scale meter may be used to set and monitor either channel-width



Labgear's D.4141 analyser can be used with scintillation counters for pulse height spectra studies

or threshold-level by the operation of a push-button.

★ **No 220**

IN BRIEF

• **Contamination removal.** Atomic Products' 'Radiocwash' for removing radioactive particles from surfaces, is a liquid compound that acts as a surface-wetting and sequestering agent.

★ **No 221**

• **Nuclear vacuum cleaner.** The new Cimex-Fraser vacuum machine consists of two aluminium containers. One has a primary filter and a PVC collector bag giving penetration of down to 2 microns. The other houses a secondary filter with penetration down to 0·5–0·1 micron. Second-stage filter area is 40 ft².

★ **No 222**

• **Electrical connector.** Belling-Lee have introduced a new principle of plug-and-socket construction in which every pin of a multi-connector is individually locked into its mating socket. This ensures positive connection of all poles under conditions of shock and vibration.

★ **No 223**

• **Phase angle voltmeter.** North Atlantic's VM-204 voltmeter, available for use at any of three frequencies from 60 to 4500 c/s, reads nulls, phase angle, total, quadrature and in-phase voltages directly, without the need for computations. Measurement range is 1 mV to 300 V, full scale in twelve range steps.

★ **No 224**

• **Electrolytic analysis.** The Wadsworth A1654 controlled cathode electrolyser, with a maximum output of 10 amps, overcomes the problem of manual control of potential. It can be used in polarography for the preliminary separation of otherwise interfering ions.

★ **No 225**

• **Portable thermometer.** The Mavotherm from Aveley Electric is suitable for rapid measurement of ambient or static temperatures in solids, liquids and gases. Battery operated, and supplied with two probes, it has two ranges: −20°C to + 90°C and + 90°C to + 200°C.

★ **No 226**

• **Magnetic recorder.** Gresham's A/25/RP multitrack head is designed for use with either magnetic tape or drum and may be used in-contact or out-of-contact with the recording medium. For analogue work, it is suitable for direct recording using a.c. bias, frequency modulations, amplitude modulation, or pulse-width modulation. For digital recording, the two windings per track are convenient.

★ **No 227**

• **Ion exchange.** Amberlite 200, which is a new ion exchange resin from Rohm and Haas, can be used when conventional resins de-crosslink, for the rejuvenation of plating solutions and for mixed-bed (Monobed) deionization. It is also suggested for use in the treatment of highly aggressive solutions or where high operating temperatures are involved.

★ **No 228**

• **Flexistrip connectors.** Belling-Lee have adapted their standard printed circuit connector L.1369 for use with the 'Flexistrip' cable to form an 8-way cable-to-cable connector.

★ **No 229**

• **Stabilized power.** The model PP5 instrument from Advance Components provides a stabilized d.c. supply, continuously variable in one calibrated range from 0 to 15 volts at a maximum current of 500 milliamps. Source impedance at d.c. is less than 0·01 ohms and the maximum ripple voltage is less than 1 mV peak-to-peak.

★ **No 230**

• **Handling equipment.** The Radiarm, SR, marketed by Atomic Products, is a positive pressure 'squeeze-to-release' remote handling tongs featuring three interchangeable shafts and two interchangeable jaws, varying in length from 22 in. to 46 in.

★ **No 231**

• **Heat treatment.** Incandescent's new batch furnace, uses the Jetube radiant heating element, incorporates integral recuperation, and can be applied for all general and controlled atmosphere heat treatments from 700 to 1000°C. The largest standard size furnace is 48 in. long, 36 in. wide and 18 in. high.

★ **No 232**

STUDENTS' NOTEBOOK

GROUNDWORK—Careers

What opportunities are there in the nuclear field for the young scientist?—3

Present achievements in the development of nuclear power have been made possible by significant contributions from each major branch of the sciences and only by their integration to a stage where theory has been put to practice. As for the physicist, the chemist and the chemical engineer, each play an important part as we have shown in our earlier articles. The engineer, however, with the task of keeping pace with the scientist, uses his professional skill to apply their theories to the design, construction, operation and maintenance of practical machines.

The Engineer. Opportunities in the nuclear industry are extremely varied. The engineer may contribute to basic thinking that leads to new developments; or he may be responsible for feasibility studies of new reactor systems. A larger number will be required to design and build the experimental equipment needed to follow particular lines of research. Throughout, the basic qualifications are ingenuity and resourcefulness combined with fundamental engineering knowledge.

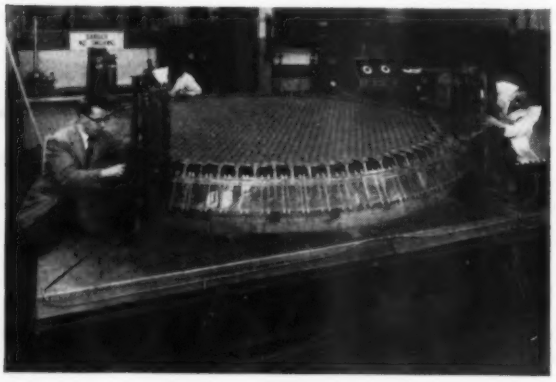
Research and development problems under study include fuel element heat transfer; boiling water and steam behaviour; the hydrodynamic differences between slurries and true liquids; liquid metals techniques necessitating leak free circuits; carefully controlled local temperatures; intricate and accurate instrumentation; and the development of special equipment and components to go with the use of new materials and techniques.

On the research side, very advanced types of particle accelerators are being designed for studying the structure of matter, and these involve difficult electrical and engineering problems. Within the reactor, loop experiments are designed for radiation studies and other effects. Apart from the problems involved by work at high temperatures and pressures, an exciting challenge is offered by the development of experimental machines for research into controlled thermonuclear reactions.

Facilities and Training. The Atomic Energy Authority and private industry are equipped with good laboratories for the furtherance of this development. Most of the universities and colleges that run Nuclear Engineering courses offer such equipment as the particle accelerator, the reactor simulator, heat transfer rigs, or subcritical assemblies. Queen Mary College in London has access to a 2 MW and a 10 kW reactor, whilst the Imperial College is building a 10 kW research reactor of its own. Another is proposed for Brunel Technical College. These courses, which usually run for a year, are intended for graduates and offer a nuclear engineering diploma. For the working non-graduate, evening and part-time courses are available at some of the London polytechnics and at certain provincial institutes of technology, or colleges of advanced technology.

A number of paths lead to mechanical engineering qualifications and they depend largely on the educational attainment and potential of the individual. For the Student Apprentice, the minimum age for entry is 16 years with a General Certificate of Education at 'O' level (in four to five subjects), or 18–19 years where 'A' level in Mathematics and Physics has been obtained. During apprenticeship, leading to first appointment, practical training at the works is given concurrently with part-time day and evening study. This leads to the award of the Ordinary National Cert ficate, normally at the age of 19, and the Higher National Certificate after a further two years study. Alternatively, students with GCE at 'O' level may undertake a two-year sandwich scheme, whilst those with GCE at 'A' level can take a three-year sandwich course leading to the Higher National Diploma, or a four-year sandwich course leading to the Dip. Tech.(Eng.).

The Graduate Apprentice may go direct to industry after completing his B.Sc.(Eng.) degree for a comprehensive industrial training, or spend the first year in industry, followed by three years on a degree course and a final year in industry. A guide to the various facilities offered by industry, both for students and graduates, can be obtained from the Institution of Mechanical Engineers. In addition, this body's rules for examinations should be obtained to see what exemptions are allowed.



Typical of experimental facilities used in the nuclear industry, this model was constructed by GEC at Erith to test stability, under thermal expansion, of a graphite reactor core using hexagonal bricks

FILMS

- Three films on the SNAP Experimental reactor are available from Atomics International. The latest, running for 12 minutes, covers the power conversion system.
- A Czechoslovakian film on the Betatron is being screened at the Cardiff annual meeting of the British Association, August 31–September 7. Running time, 15 minutes. Also available on hire from Plato Films, London.

UK COURSES

Battersea College of Technology, London Transformation of Austenite. September 27–30. Fee: £12 12s.

Birmingham University One-year M.Sc. courses commencing October: Reactor Physics and Technology, Fee: £81; Radioactivity, Fee: £81; Radiobiology, Fee: £95.

Borough Polytechnic, London Nuclear Physics for Nuclear Power—11 lectures commencing October 6. Nuclear Circuitry —10 lectures commencing October 5. Nucleonic Techniques and Measurements —2 months full-time or part-time course starting October 7.

Calder Operation School Reactor Operation. 5 weeks course commencing October. Fee: £125.

Durham University Radiochemistry. 1 year M.Sc. course beginning October.

Glasgow Royal College of Science and Technology Nuclear Power Engineering. 1 year Diploma course commencing October. Fee: £55. Nuclear Technology (Chemical) 1 year Diploma course commencing October. Fee: £64.

Imperial College of Science and Technology, London Nuclear Power. Nuclear Technology (chemical). 1 year diploma courses beginning October. Fees: £64 and £124 respectively.

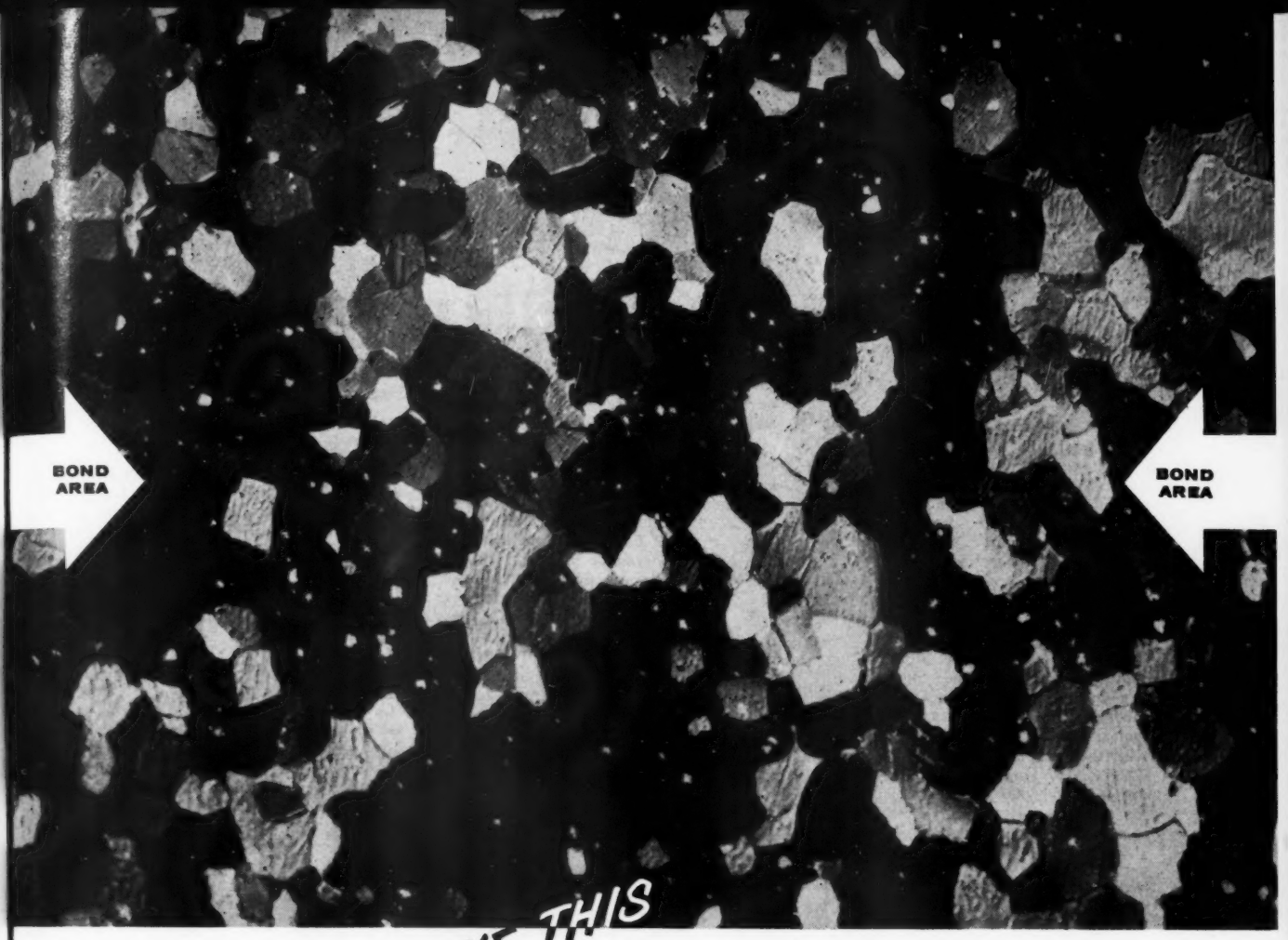
Leicester College of Technology General basic course in Radiochemistry. 1½ years diploma course starting October. Fee: £50.

Manchester University Nuclear Engineering. 1 year diploma course commencing October. Fee: £46.

Northampton College of Advanced Technology, London Introduction to Nuclear Power. 20 weeks course commencing October 6. Engineering design of nuclear Power Plant. 18 weeks course commencing October 11. Fee: £3 3s.

Queen Mary College, London Nuclear Engineering. Postgraduate course commencing October. Fee: £90.

Salford Royal Technical College Introduction to Nuclear Power Technology. 8 weeks course commencing October. Fee: £60.



LIKE THIS

BONDS ARE OUR BUSINESS

A high-integrity metallurgical bond between fuel and cladding is your best guarantee against void-induced fuel cladding failures.

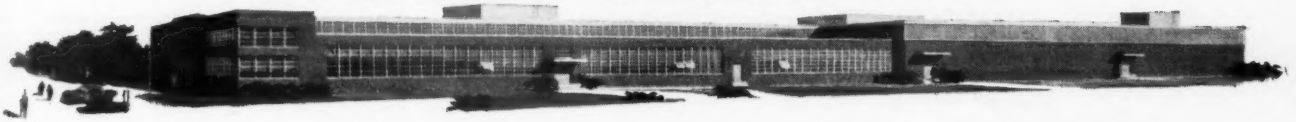
Element processing that eliminates bond line defects and exhibits grain growth across interfaces can enhance fuel life and reactor performance.

M & C Nuclear's superior experience and technical knowledge in bonding metals is widely recognized in the nuclear industry. Elements bonded by hot rolling, cold rolling, coextrusion, brazing, welding, and pressing have been made in production quantities. We are also equipped to check the integrity of our bonds by metallographic examination and the nondestructive methods such as radiography and ultrasonic testing.

Our bonding skill is another reason that M & C Nuclear fuel elements contribute to efficient reactor operations. Let us confer with you in an early stage of your reactor design project to assure the greatest economies in fuel element utilization.

Another example of M & C's technical skills in the nuclear industry.

TEXAS INSTRUMENTS
INCORPORATED
M&C NUCLEAR, INC.
(A SUBSIDIARY)
P. O. BOX 898 • ATTLEBORO, MASSACHUSETTS, U. S. A.



The World's Largest Privately Owned Facility Designed Specifically for Fabrication-Development and Production of Fuel Elements, Core Components and Complete Cores.

BUSINESS NEWS

UNITED POWER COMPANY The name of the new group formed by the *GEC/Simon-Carves Group* and *Atomic Power Constructions* is to be the *United Power Company* (see *Business News*, August). According to Sir Leslie Gamage, chairman of GEC, this new concern would be devoted to nuclear power work but this did not preclude, at some later date, an extension to other related fields.

Sir Leslie also pointed out in his annual report to shareholders that GEC entered the current year with an order book of £M138 against £M133 last year, both including some £M56 for atomic energy contracts. However, the company still thought it prudent to provide a further £500,000 out of its profits of over £M4 against the Hunterston contract. Last year, the company made a provision of £250,000 for Hunterston. This compares with the £500,000 that John Thompson has transferred from its general reserve to a special nuclear contracts reserve.

NEW COMPANY FORMED A new company, *D. S. Hilton & Co.* of Cheshire, has been formed to pack and distribute activated alumina, the dessicant to be used in certain equipment supplied to the *UKAEA* and the *Central Electricity Generating Board*. Packages of sizes suitable for placing in such equipment is made, the standard packs being one, two, four and eight ounces in cotton or linen bags.

INSTRUMENT COMPANIES MERGE *Cambridge Instrument Company Ltd.'s* offer for the shares of *Electronic Instruments Ltd.* of Richmond has been accepted by the shareholders and the merger of the two companies has now been completed (see *Business News*, August). The Richmond concern will continue to trade under its own name but research, production and sales facilities will be co-ordinated.

Another purchase is that of *Mancuna Engineering Ltd.* by *Sturtevant Engineering Co. Ltd.*; this clarifies our report, this page, last month.

SOLARTRON'S AEA CONTRACT A team of nearly 30 engineers is expected to be working on the instrumentation and control apparatus for the Intermediate Current Stability Experiment (ICSE) at the AEA's new thermonuclear laboratory at Culham. They will come from the *Solartron Electronic Group Ltd.* who have been awarded a contract for this work which includes the design and manufacture of the control room apparatus. In some aspects of the work Solartron will be assisted by *Gresham-Lion Electronics Ltd.*

EMI-SAAB AGREEMENT A co-operative agreement under which each firm will market the other's products has been signed by *EMI Electronics* and the Swedish *SAAB Company*. In future, SAAB will sell EMI's equipment throughout Sweden, Norway and Denmark through their sales organization, *SAAB Electronics*. Similarly, EMI Electronics will market SAAB products in the British Commonwealth and other countries. In addition, the two companies have agreed to exchange technical information and licences in the future.

JOHN THOMPSON AND DUNGENESS The order for the Dungeness station secured by *The Nuclear Power Group* will bring contracts worth approximately £M7 to *John Thompson Ltd.* and its associated companies. This will increase work on hand uninvoiced at the present time to £M39 which is £M10 more than the corresponding figure at the end of 1959. Sir Edward Thompson, chairman of the company, told the annual meeting. Earlier, Sir Edward had said that losses were anticipated on atomic energy contracts, particularly on the Berkeley station. These were most disappointing as after the original White Paper on Nuclear Power, a continuing output in nuclear power work had been expected. But this had not materialized and development costs could not be spread.

HAWKER SIDDELEY'S OEEC PROJECT Final quotations and contract negotiations between *AEK*, Denmark, and the *Hawker Siddeley Nuclear Power Co.* are awaited for the supply of a capsule rig to replace one of the corner fuel elements in the reactor DR3, says the OEEC Dragon annual report. The rig, to be commissioned and installed during October 1960, will be used for irradiation of Dragon fuel samples.

OVERSEAS

FRANCO-US COMPUTER COMPANY A new joint Franco-US company, for the sale of computers, has been formed by *Thompson Ramo Wooldridge Inc.* of California, *Compagnie Générale de Télégraphie Sans Fil* (*CSF*) and *Intertechnique* of France. The new corporation, *Compagnie Europeénne d'Automatisme Electronique*, will have its headquarters in Paris and will manufacture and sell the American firms's RW-300 digital control computer.

GE's AUTOMATION PLANS A three-year programme to place the production of nuclear equipment on an automatic basis has been started by the US *General Electric Company*. At its San Jose, California, plant, where the programme will be implemented, an automatically controlled turret drill is already in operation and seven more automatic devices are due for installation by the end of 1961.

URANIUM IN AIRCRAFT Steps to make it easier to use uranium as counterweights in aircraft have been taken by the *US Atomic Energy Commission*. A licence is now no longer required for uranium if it is used for this purpose. Depleted uranium is used for counterweights in wing tips and tail pieces of jet commercial planes with as much as 300 lb being used in a single jet airliner.

COMPUTER CONTRACT A £540,000 contract for computers of the type seen above at the UKAEA's Winfrith establishment has been awarded to Electronic Associates Inc. of the US by the National Aeronautics and Space Administration (NASA). The system, described as the largest and most advanced general purpose analogue computer in the world, will be made up of five separate PACE 231R systems and will be 132 feet long

Expansion, contraction and lateral movement of pipe work under extreme conditions of temperature and pressure is no problem to the engineer who has been wise enough to contact and consult TEDDINGTON technicians.

Teddington Bellows Expansion Joint cylinders are butt-welded from highly finished cold rolled stainless steel sheet. Convolutions are introduced to give the bellows their characteristic flexibility. Nuclear, chemical, marine and gas engineers acknowledge their efficiency and superiority over many older forms of expansion joint. Wherever pipework is subjected to vibration or movement in any direction, a Teddington Bellows with a suitable end-fitting will solve the problem.

SEND FOR BROCHURE No. R 97

Made under licence from the Solar Aircraft Co., California, U.S.A.

TEDDINGTON BELLOWS
EXPANSION JOINTS

TEDDINGTON AIRCRAFT CONTROLS LIMITED, (*Industrial Bellows Division*)
Ammanford, Carmarthenshire. Tel: Ammanford 2255

Diary

25 AUGUST—1 SEPTEMBER
Tenth International Conference on *High Energy Nuclear Physics*, International Union of Pure and Applied Physics and Commission on High Energy Physics at Rochester, New York, USA

29 AUGUST—2 SEPTEMBER
Initial effects of radiation on living cells, UNESCO symposium, USSR Academy of Sciences, Moscow
International Conference on *Semiconductor Physics*, Prague, Czechoslovakia. Enquiries Dr. Milos Matyas, Institute of Technological Physics, Cukrovarnicka 10, Prague 5

29 AUGUST—3 SEPTEMBER
International Conference on *Nuclear Structure* at Queen's University, Kingston, Ontario, Canada. Details, Dr. L. G. Elliott, Atomic Energy of Canada, Chalk River, Ontario
Seventh International Conference on *Low Temperature Physics*, Toronto. Details, Professor H. Hallett, Dept. of Physics, University of Toronto, Ont., Canada
Use of Radioactive Isotopes in the study of bone, International Research Symposium, New York. Details, Council for International Organizations of Medical Sciences, 6 rue Franklin, Paris 16e, France

31 AUGUST—7 SEPTEMBER
Annual meeting at Cardiff of the British Association for the Advancement of Science

31 AUGUST—11 SEPTEMBER
St. Eriks Fair, Stockholm. Capital and consumers goods, with specialist sections

1 SEPTEMBER
Rocket and Satellite Instrumentation One day symposium by the Society of Instrument Technology and the British Interplanetary Society in London

1–7 SEPTEMBER
Fifth International Congress on *Nutrition*, Washington. Details, General Secretary, 9650 Wisconsin Avenue, Washington 14, USA

5–8 SEPTEMBER
Legal and Administrative Problems of Protection in the field of peaceful applications of Atomic Energy, International Euratom Symposium, Brussels

5–9 SEPTEMBER
IAEA Conference on *medium and small power reactors*, Vienna

6–7 SEPTEMBER
Fundamental Aspects of Atomic Reactions, Symposium, Montreal. Details, Chemical Institute of Canada, 48 Rideau Street, Ottawa 2, Canada

6–8 SEPTEMBER
Nuclear and Radiochemistry Symposium, Chalk River, Canada. Details, Dr. R. H. Betts, Atomic Energy of Canada Ltd., Chalk River, Ontario, Canada

6–17 SEPTEMBER
IAEA Conference on *Use of Radioisotopes in Physical Sciences and Industry*. Copenhagen

7 SEPTEMBER
The History of Boilers by W. Renton at Edinburgh, Institution of Plant Engineers

7–18 SEPTEMBER
Summer meeting on *The Structure of Nuclei* with special emphasis on problems of nuclear reactions, Hercegnovi, Yugoslavia. Details, Ing. Ljubomin Barbaric, Yugoslavia Nuclear Energy Commission, Belgrade

11–16 SEPTEMBER
138th meeting of the American Chemical Society and 1960 Chemical Exhibition, New York

12–14 SEPTEMBER
International Conference on *Instrumentation for High Energy Physics*, Berkley, California. Details, Dr. Hugh Bradner, University of California, Lawrence Radiation Laboratory, Berkeley, Calif., USA

12–15 SEPTEMBER
International Conference on *Atomic Masses*, Hamilton, Ontario. Details, Prof. H. E. Duckworth, Dept. of Physics, McMaster University, Hamilton, Ontario, Canada

13–16 SEPTEMBER
Fifth International *Instruments and Measurements Conference*, Stockholm. Details, Tekn. Lic. Helge von Koch, Kungl. Teknska, Hopkolan, Stockholm 70

14–16 SEPTEMBER
American Management Association Seminar on *Atomic Hazards*, New York. Details, Course Registrar, AMA, 1515 Broadway, New York 36

14–19 SEPTEMBER
21st National Congress of the Italian Society of *Medical Radiology and Nuclear Medicine*, Bologna, Italy

15 SEPTEMBER
New Developments in Fuel and Power Technology, Professor M. W. Thring, at Blackburn, Institution of Plant Engineers

21 SEPTEMBER—1 OCTOBER
International Factory Equipment Exhibition at Belle Vue, Manchester

21–23 SEPTEMBER
High Temperature Resistance and Thermal Degradation of Polymers. Three-day symposium by the Society of Chemical Industry at the William Beveridge Hall, Senate House, University of London, London, WC1
Power Conference, American Society of Mechanical Engineers and American Institute of Electrical Engineers at Philadelphia, Pennsylvania, USA

22–23 SEPTEMBER
The protection of gas plant and equipment from corrosion, Society of Chemical Industry, Institution of Gas Engineers and Birmingham College of Advanced Technology, at Birmingham

22–24 SEPTEMBER
Theory and practice of Ultrasonic Inspection, Conference, Cheltenham. Details, I. M. Barnes, Materials Laboratory, de Havilland Propellers Ltd., Hatfield, Herts

25–28 SEPTEMBER
American Institute of Chemical Engineers Meeting on *corrosion of construction materials and chemical reactions induced or modified by ionizing radiation*, Tulsa, USA

26–30 SEPTEMBER
15th Annual *Instrument-Automation* Conference and Exhibit, New York. Details, Instrument Society of America, 313 Sixth Avenue, Pittsburgh 22, Pa., USA

27 SEPTEMBER
The Maintenance Problems in a Nuclear Power Station: J. R. Treharne, at Sheffield, Institution of Plant Engineers

27–30 SEPTEMBER
Power Systems Conference, American Rocket Society, Santa Monica, California. Details, Roderick L. Hole, American Rocket Society, 500 Fifth Avenue, New York 36

29 SEPTEMBER
The Extraction of Metals and the Chemistry of Metals, Fourth Robert Horne Memorial Lecture, by Prof. F. D. Richardson, University of Bristol. Details, Society of Chemical Industry, London, SW1

Future months

3–7 OCTOBER
Fifth International Atomic Energy Seminar, Wiesbaden, Germany. Details, Mr. Trebst, Internationale Studiengesellschaft e.V., Theodorenstr 6–8, Wiesbaden

14–18 NOVEMBER
IAEA *Nuclear Ship Propulsion and Safety Symposium*, Taorima, Sicily

Industrial Literature

Temperature measurement. Electrothermal's latest leaflet details two electronic temperature indicators, the Tastotherm for contact measurements up to 400°C, and the Tastotherm Infra which, by radiation, measures temperatures up to 3000°C.
★ No 249

Hydraulic systems. Of interest to design engineers is Wakefield-Dick's handbook 'Hydraulic oils' that includes chapters on fundamental hydraulic principles; pumps and components; and hydraulic fluids.
★ No 250

Nuclear materials. A new brochure from the Metals Division of ICI gives brief notes on the properties, production and application of titanium, zirconium, beryllium, hafnium, niobium and vanadium.
★ No 251

Stress relieving. Cooper Electroheat's handbook on the application of electrical elements in the preheat and stress relief of welds, includes nuclear applications to heat exchangers, CO_2 ducting, reactor seams and nozzles.
★ No 252

Flow measurement. Kent's leaflet on orifice fittings covers standard equipment for steam, air, gas or liquid flow measurement.
★ No 253

Thermal insulation. Cape Asbestos' new technical bulletin includes an article on some of the insulation problems being dealt with at Berkeley.
★ No 254

Nuclear instrumentation. Tracerlab's current catalogue gives the specifications for a full range of instruments that includes: counting systems, scalers, spectrometers and amplifiers, ratemeters, scintillation equipment, radioactive sources, and safety equipment.
★ No 255

Flow measurement. The June issue of 'de Havilland Gazette' contains details of a new rotor type flow meter that is to be made available in sizes ranging from ¼ in. up to 22 in. dia., and covering a flow range of one-tenth gal/min up to 40,000 gal/min.
★ No 256

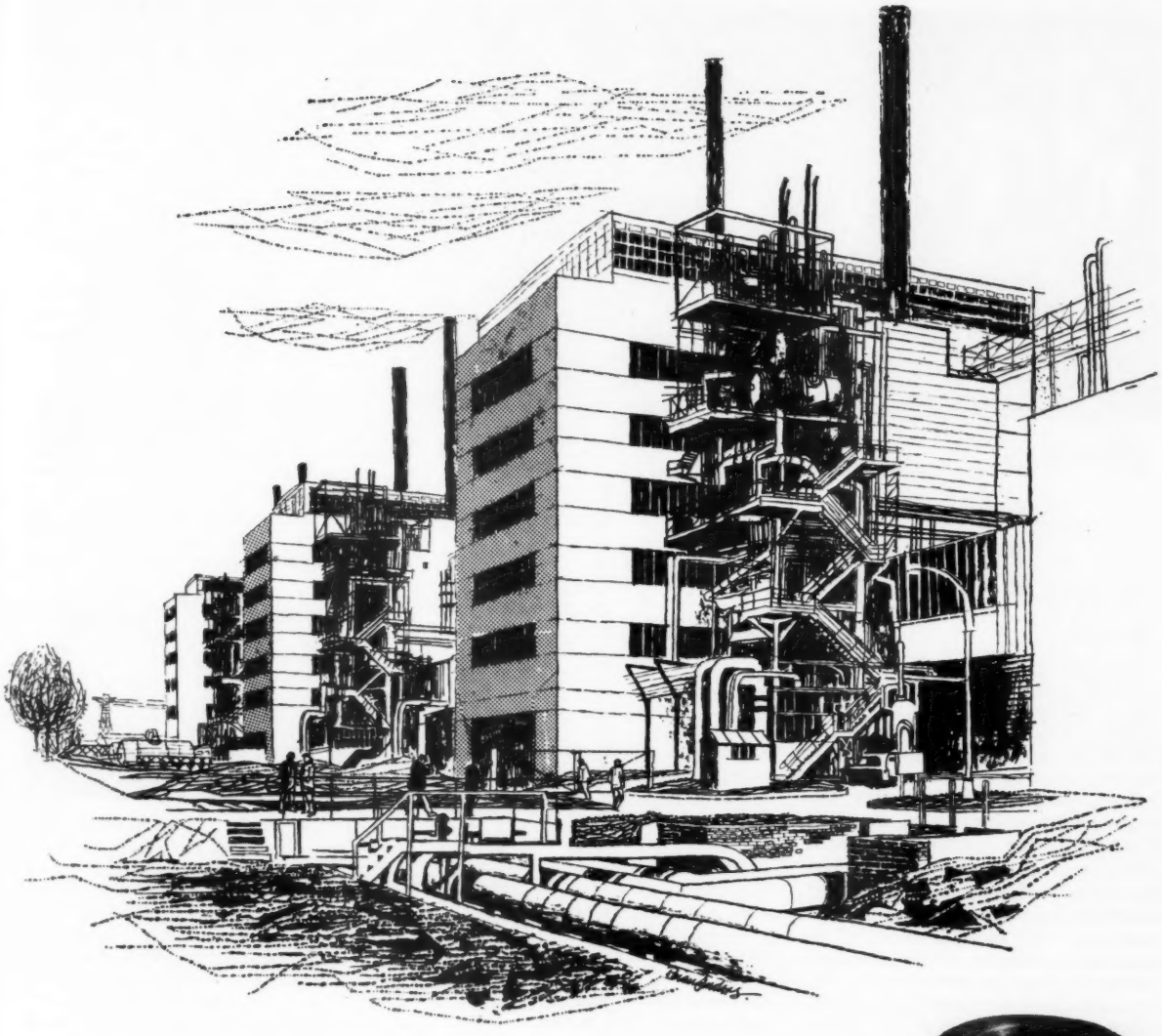
Welding guide. The Suffolk Iron Foundry are publishing a series of welding data charts, the first of which gives, against all the commercial metals in general use, weld preparation details and other essential data.
★ No 257

Photomultiplier tubes. The latest leaflet from 20th Century tabulates various mechanical and electrical properties against their range of tube types.
★ No 258

Welding equipment. Two recent publications from Murex cover the equipment and applications for 'Muramatic' welding by the submerged- and open-arc processes, and for arc welding.
★ No 259

Flaw detector. The working principles and techniques of a new portable pulsed ultrasonic flaw detector are outlined in a leaflet from Branson Instruments.
★ No 260

** For further information on any item circle the appropriate number on the reply card facing page 162.*



the applications of Ermeto high pressure couplings are practically unlimited

Ermeto high pressure couplings are specified by many leading manufacturers because of their proven reliability under arduous conditions. They are available in mild and stainless steel, brass and aluminium alloy. Couplings, valves and flexible hose are supplied in a wide range of standard fittings. Non-standard fittings can also be made to meet your specifications. Technical information and our illustrated catalogue are freely available on request.

ERMETO

BRITISH ERMETO CORPORATION LTD

HARGRAVE ROAD · MAIDENHEAD · BERKS · TELEPHONE: MAIDENHEAD 5100

A member of the ALENCO Group of Companies

Circle **No 84** on reply card for further details

WELDING MISSION RETURNS Our picture, left, shows members of the British Welding Delegation to Russia shortly after their return home. In the picture (left to right) are R. H. Boughton, English Electric; W. S. Simmie, Pressed Steel Co. Ltd.; G. H. Moule, AEI; T. F. Tribe, British Federal Welder & Machine Co. Ltd.; G. M. Harvey, British Oxygen Gases Ltd., and R. L. Swan, Lincoln Electric Co. Ltd. Missing is Dr. D. Wyllie, of Babcock and Wilcox, who was taken ill in Moscow the day the delegation was to return. He is expected to be in hospital for some time

People

by John Radford

CHANGES at the top at Harwell have resulted in **Dr. F. A. Vick,** former deputy director, being appointed director, **Dr. R. Spence,** chief chemist, being appointed as deputy director and **Mr. L. Grainger,** former head of the metallurgy division, being appointed assistant director. **Sir Basil Schonland,** who received his knighthood in the 1960 Birthday Honours List, continues as Director of the Research Group of which Harwell is a part. Dr. Vick, a Birmingham University graduate, was Professor of Physics at the University College of North Staffordshire before joining Harwell. His colleague, Dr. Spence, was with the Atomic Energy Research Group under Sir John Cockcroft in Montreal in 1945, moved to Chalk River that same year and came to Harwell in 1947. Mr. Grainger, who was educated in Detroit, joined the AEA nine years ago after service with the Admiralty.

Dealing with the Pace computing equipment manufactured by Electronic Associates Inc. will be one of the tasks facing **Mr. Peter A. Wright,** who was recently appointed sales manager at the firm's Burgess Hill head office. Mr. Wright was previously in charge of analogue computer sales at Short Bros. and Harland Ltd.

When **Sir Leslie Gamage** announced his retirement as chairman and managing director of the General Electric Co. Ltd., I was somewhat taken by surprise. His term of office was so successful that I expected he would continue on for some time. However, as Sir Leslie said 'I have to realize that the task I have set myself is nearly done and it is time for me to take a less active part so as to allow younger men to build up on these better foundations'. He was here referring to the better results achieved by GEC last year and, in fact, since he took office as chairman three years ago when he devoted himself to its re-organization and the restoration of its profitability. Sir Leslie joined the company in 1919.

I, however, was not surprised to hear that **Mr. Adam K. Kirk,** the founder of Kirk & Co. (Tubes) Ltd., had been elected to the 'High Office of Sheriff for the City of London'. For he has had a long and

Sir LESLIE GAMAGE
retires soon

ADAM KIRK
City Sheriff

respected association with the City as a Freeman and a Liveryman of the Worshipful Companies of Poulters, Founders, Joiners. What is perhaps not as well known is that Mr. Kirk was born in the small township of Balranald, New South Wales; he settled in England in 1919 after service with the 1st Australian Division at Gallipoli, the Somme and Passchendale.

Three recent changes have been announced by C. A. Parsons & Co., Ltd. **Mr. E. C. Rippon,** formerly chief transformer engineer, is now to assist the managing director on the organization of design and production throughout the works; he is also to be consultant to the company's Transformer Division. Taking

E. C. RIPPON

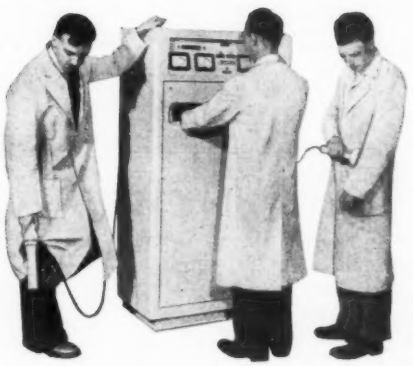
ROBERT BRUCE
move up at Parsons

his place as chief transformer engineer is **Mr. Robert Bruce,** his deputy for a number of years. The last change is at the company's London office where **Mr. G. A. S. Bartley** has been appointed manager; he succeeds **Mr. John Packard,** who, following a recent illness, asked to be relieved of some of his responsibilities. Mr. Packard will, however, remain as deputy manager.

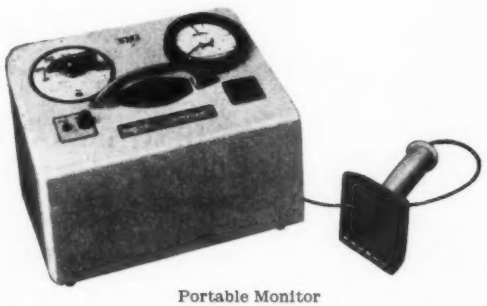
Sales appointments to 'meet the requirements of the company's expanding facilities and markets' in the US and abroad have been announced by High Voltage Engineering Corporation of the US. This follows the establishment of High Voltage Engineering (Europa) NV in Holland and the acquisition of Applied Radiation Corporation in California. Sales manager is to be **Mr. Henry S. Lodge** with **Mr. D. A. Trageser** as manager of domestic sales while **Mr. James H. Bly,** who formerly was head of technical sales, is now director of science applications, a newly created post.

A new appointment to the board of directors of Atomic Industrial Forum has been made in the person of **Mr. E. V. Murphree,** president of Esso Research & Engineering Co.

NUCLEAR SAFEGUARDS



Hand and Clothing Monitor



Portable Monitor

E.M.I. INSTRUMENTS PROTECT AGAINST RADIATION HAZARDS

The Hand and Clothing Monitor has been specially designed to cope with large numbers of staff. Whilst Alpha and Beta contamination are being simultaneously checked on both hands, the footwear and clothing of two other workers are being screened.

The speed, simplicity and safety of E.M.I.'s new Monitor have been recognised by large orders from the U.K.A.E.A. and authorities in many other countries.

- ✳ Complete Alpha and Beta hand count in 5 seconds.
- ✳ Audible and visible warning of the maximum permissible contamination level.
- ✳ Audible warning if hands are removed too soon.
- ✳ Dual phosphor scintillation counters for increased efficiency in tropical and humid environments.
- ✳ Automatic correction for background radiation.

The Portable Monitor is the answer where mobility is required. Compactness *and* high accuracy have been achieved by combining all-transistor circuitry with the E.M.I. dual phosphor technique. This instrument, developed in close collaboration with U.K.A.E.A., marks a really significant step-forward in radiation detection.

- ✳ Simultaneous monitoring of Alpha-Beta radiation, giving aural and visual warnings.
- ✳ Transistors throughout for reliability, lower power consumption and long life.
- ✳ Battery operation for real portability (mains unit available if required).
- ✳ High accuracy over wide temperature range.

Write or telephone now for a demonstration and full details

E.M.I. ELECTRONICS LTD

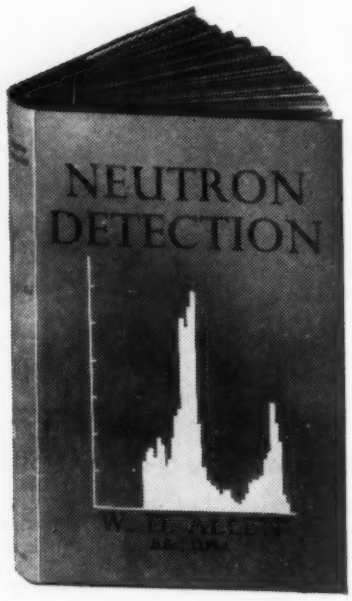
INSTRUMENT DIVISION · HAYES · MIDDLESEX

TELEPHONE: SOUTHALL 2468

EE 113

Just published!

NEUTRON DETECTION



by **W. D. ALLEN**

B.Sc., D.Phil.

This book is addressed to those who, with some background knowledge of nuclear physics and particle detectors, require a more detailed knowledge of the main methods of neutron detection. Dr. Allen has been concerned at Harwell with the measurement of fast fission cross sections, and therefore with the measurement of fast neutron flux. While his main interests are in the field of fast neutron physics, his work has brought him into contact with a variety of neutron measurements and techniques at Harwell.

With many line diagrams and graphs

45s. net

FROM ALL BOOKSELLERS

. . . or in case of difficulty, send a remittance of 46s. 3d. to the publishers, George Newnes, Ltd., Tower House, Southampton Street, London, W.C.2.

NEWNES

★ 262

Book Reviews

Welding practice

High Productivity in Heavy Engineering Production, Inspection and Cost Control in Welded Fabrication by A. G. Thompson 1960 Iliffe, London 339 pp Price 65s

Rapid development of the use of welded fabrication in heavy engineering has produced particular problems in this field, not only technical, but also in other aspects such as work measurement, cost control, etc. In present conditions of keen competition and the tendency of costs to rise, a book on such matters is timely, particularly as it presents a new approach to the subject. The author wisely avoids repetition of or adding to the large volume and steady flow of published information on welding technology; and deals more particularly with other aspects of the subject on which much less is written.

After a short introductory chapter which mainly illustrates types of joints used in metal arc welding, the author deals with the layout and organization of modern fabricating shops. This chapter, and a later one on assembly and handling, are worthy of study as, in many shops engaged on this type of work, an analysis of costs will show that a high (and sometimes alarming) proportion of the total is represented by handling charges; and investigation will indicate a fruitful field for effecting economies and a smoother flow of work. In the chapter on dimensioning for accurate fabrication, various methods of transferring dimensions are explained and illustrated; it is also shown that, although cost of plate preparation rises with increased accuracy, the cost of welding decreases, therefore for a particular job there is a range of accuracy of preparation which will give the minimum total cost. A wide range of machines used in cutting and forming operations is dealt with in the chapter on the metal working processes. For each type of machine the purpose, principle, range of application and description is given, and data of capacity, power required and price range are included. Two types of computer controlled flame cutting machines are described. The electro-slag welding process, which has potential applications in heavy fabrication, is described in the chapter on welding processes, which also includes a discussion on thick plate welding for nuclear power applications. The chapter on quality control and inspection consists mainly of a review of the various methods of non-destructive examination.

New Books

● *Hyperonen und K-Mesonen* by M. A. Markow Deutscher Verlag der Wissenschaften, Berlin 1960 328 pp Price DM 42·80

★ 263

● *Applied Gamma-ray Spectrometry* edited by C. E. Crouthamel Pergamon Press, London 1960 443 pp Price 50s

★ 264

● *Nuclear Photo-Disintegration* by J. S. Levinger Oxford University Press 1960 144 pp Price 15s

★ 265

● *Russian-English Metals and Machines Dictionary*. Compiled by E. A. Carpovich, Technical Dictionaries Co., New York, 1960 112 pp Price $9

★ 266

● *Basic Principles of Nuclear Science and Reactors* by A. M. Jacobs and others, Van Nostrand Nuclear Science Series, New York and London 1960 262 pp Price 49s

★ 267

★ For further information on any item circle the appropriate number on the reply card facing page 162.

NEW BOOKS

on Atomic and Nuclear Physics

(General, Advanced and Applied) Supplied from stock. Foreign books not in stock obtained to order. Catalogues on request.

SECOND-HAND BOOKS

A constantly changing large stock of Scientific and Technical Literature on view, classified under subjects.

LENDING LIBRARY

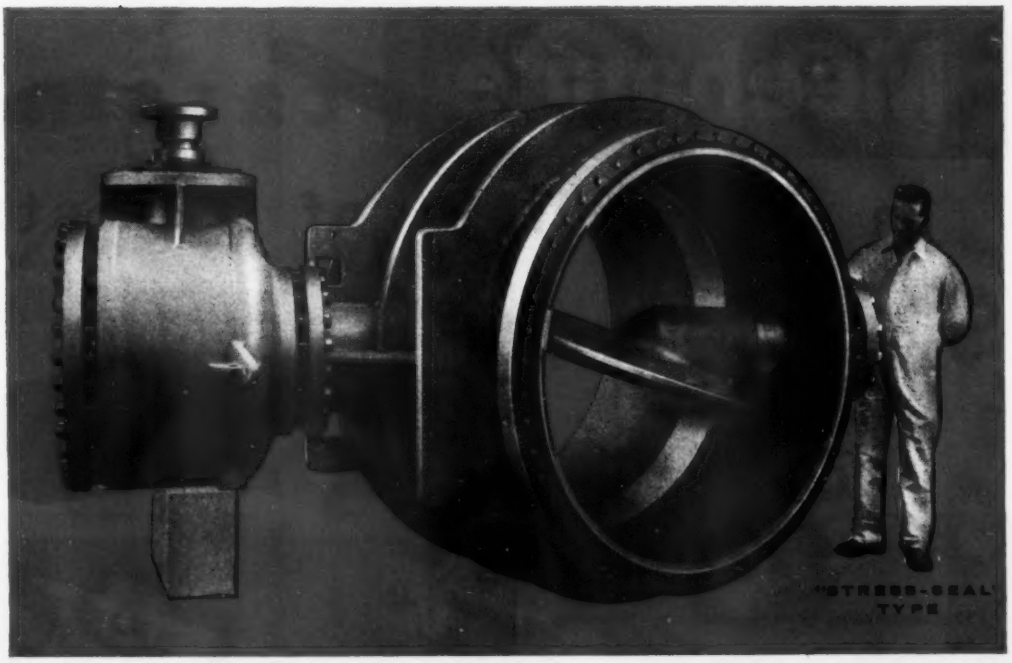
Technical and Scientific

Annual Subscription from £1 . 17 . 6. Bi-monthly list of New Books and New Editions sent post free to all subscribers on request. Prospectus post free on application.

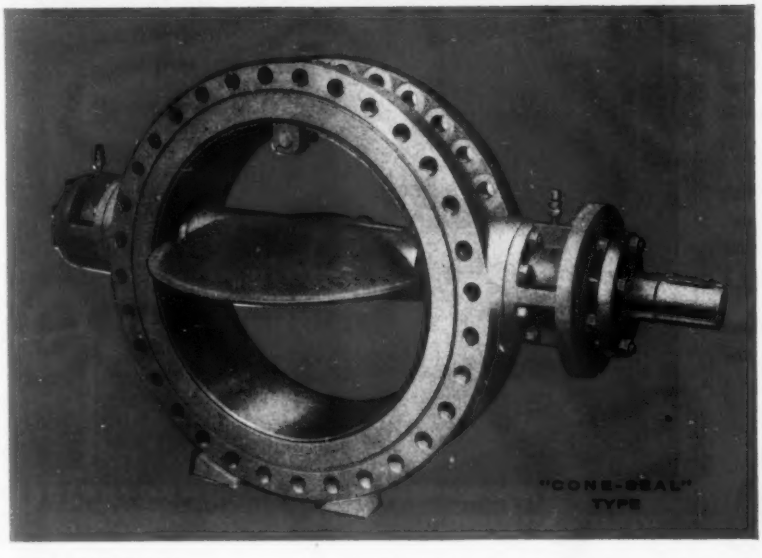
H. K. LEWIS & CO. LTD

136 Gower St. W.C.1. EUS 4282

★ 268



REACTOR GAS VALVES



Specially developed for high temperature gas duct service, Blakeborough "Cone-Seal" and "Stress-Seal" Butterfly valves have aroused particular interest in the nuclear field. The "Cone-Seal" construction is applicable to sizes up to 42 in. bore; the "Stress-Seal" from 36 in. upwards. Both give tight closure, or shut-off to very fine leakage tolerances, even under severe thermal shock conditions. They are being supplied for main duct isolating duty on the following power reactors :-

BERKELEY	"Stress-Seal" type. Thirty-two 60 in. bore. Design conditions : 137 psig. and 716° F.
TOKAI MURA	"Stress-Seal" type. Eight 66 in. bore. Design conditions : 230 psig. and 797° F.
WINDSCALE	(AGR). "Cone-Seal" type. Eight 24 in. bore. Design conditions : 300 psig. and 1067° F.
TRAWSFYNYDD	Twelve 66 in. bore. Main gas duct throttle service. Twelve 42 in. bore. By-pass service. Also : Throttle type butterfly valves (without shut-off), as at present in hand.

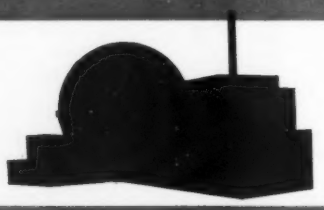
BLAKEBOROUGH

J. BLAKEBOROUGH & SONS LTD BRIGHOUSE ENGLAND

Meehanite castings

in every field of Industry

Now—the Nuclear Power Industry . . .



This outstanding press produced by Wheesoe Ltd., is the most powerful of its type in Europe. The dies used on this press are Meehanite castings.

They are used for shaping 4 inch steel plates in the construction of the spherical reactors at Bradwell and Latina Nuclear Power Stations.

Meehanite dies were chosen for their exceptional qualities—high resistance to abrasive wear, strength and frictional properties.

Meehanite dies are produced to a high standard of finish and require less labour, and machining costs, resulting in substantial savings.

Over 600 plates have already been cast from the original set of dies—proof enough of the longer service life of a Meehanite die.

Castings produced by G. McKay & Co. Ltd., Glasgow

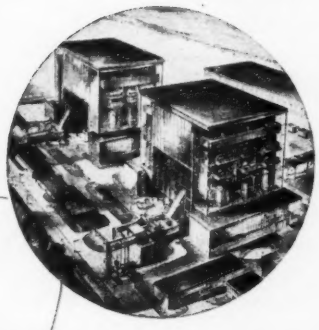
Meehanite castings give greater performance, saving both time and money

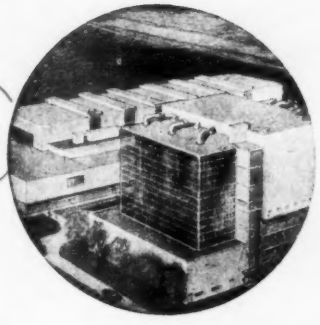
The International Meehanite Metal Co. Ltd.
Meerion House, 4 Downside
Epsom, Surrey

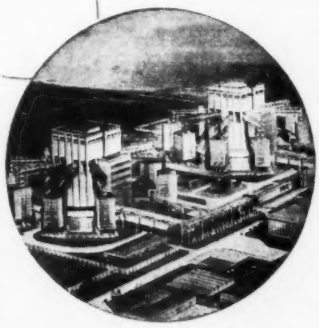
FREE OFFER

Write for the free booklet H.1. "Meehanite in the Service of Industry", containing many pages of examples of outstanding applications for Meehanite castings.

A full range of Bellows-sealed Valves for CO_2 services also available







NEWMAN-VELAN

Bonnetless Valves for Nuclear and Cryogenic Industries

FULL DETAILS ON APPLICATION

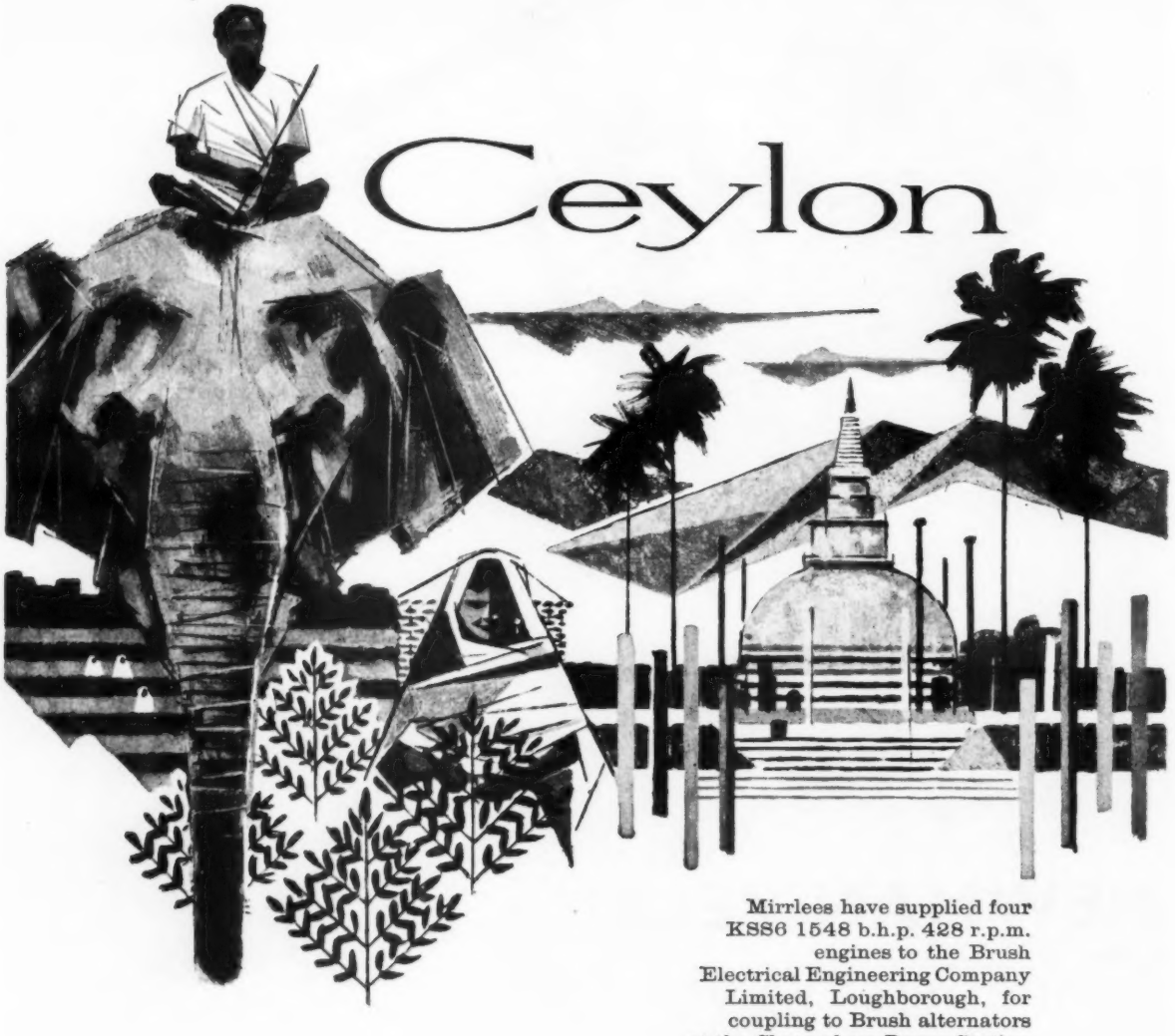
NEWMAN, HENDER & CO., LTD.

WOODCHESTER, Stroud, Glos.

Telephone: Nailsworth 360. Telex: 4375

Circle **No 88** on reply card for further details

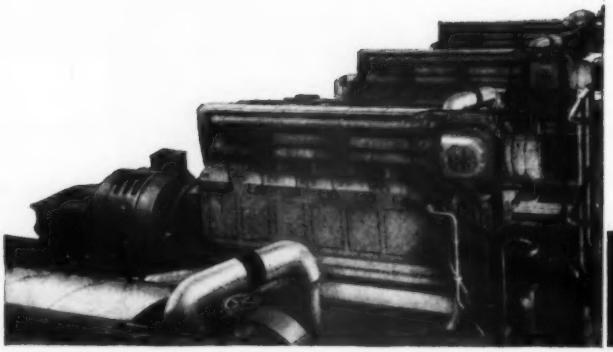
Mirrlees meets the world's power needs



Mirrlees have supplied four KS8 6 1548 b.h.p. 428 r.p.m. engines to the Brush Electrical Engineering Company Limited, Loughborough, for coupling to Brush alternators at the Chunnakam Power Station of the Ceylon Government Electrical Undertaking.

All major engine ancilliary equipment was supplied by Mirrlees whose engineers assisted in the installation and commissioning of the complete plant.

Our agents in this territory are Wm. Jacks & Co. (Ceylon) Limited, Colombo.



Mirrlees diesels

A member of the Hawker Siddeley Group

MIRRLEES, BICKERTON AND DAY LIMITED
HAZEL GROVE · STOCKPORT · CHESHIRE
Tel: Stepping Hill 1000 (15 lines) *Grams: Mirrlees, Telex, Manchester* IE 34

Circle **No 90** on reply card for further details

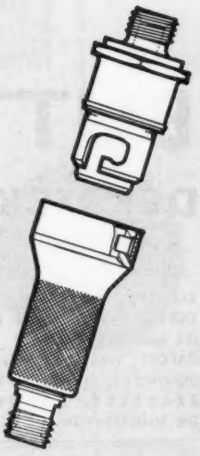
HIGH TEMPERATURE SELF-SEALING COUPLINGS

Designed initially for use with oil-fired furnaces to permit the servicing or changing of burners without shutting off the fuel supply.

As is usual with Lockheed-Avery couplings, each half-coupling seals when disconnected, and provides a clear flow when re-coupled.

For operating temperatures up to 180°C, and intermittent peaks of 250°C. For pressures up to 1500 p.s.i.

Illustrated pamphlet on application.



AVERY DIVISION, LOCKHEED PRECISION PRODUCTS LIMITED
SHAW ROAD, SPEKE, LIVERPOOL 24
Telephone: Hunts Cross 2121 Telex: 62394 Telegrams: Lockheed Liverpool 24

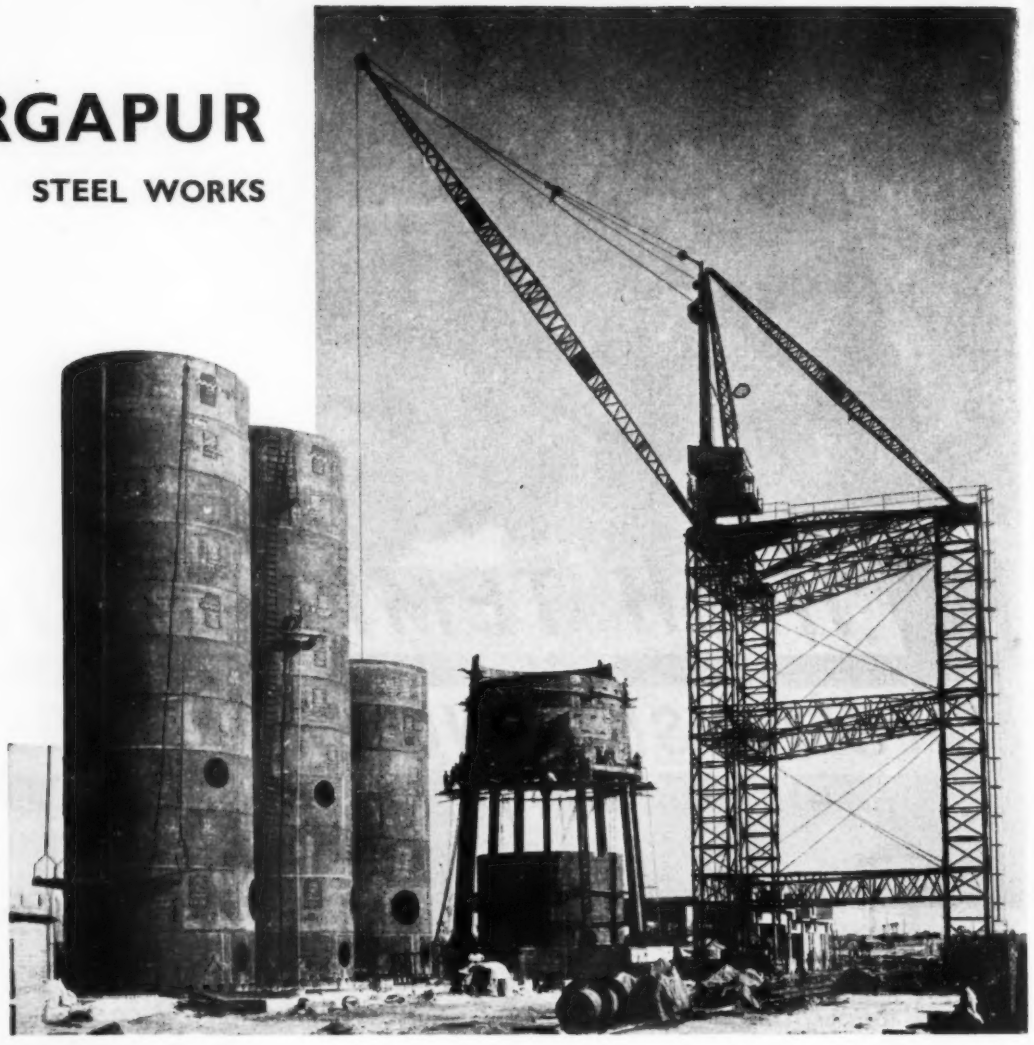
Lockheed Avery

REGD. TRADE MARK: LOCKHEED

ONE OF THE AUTOMOTIVE PRODUCTS GROUP

DURGAPUR

STEEL WORKS



BUTTERS

DERRICKS

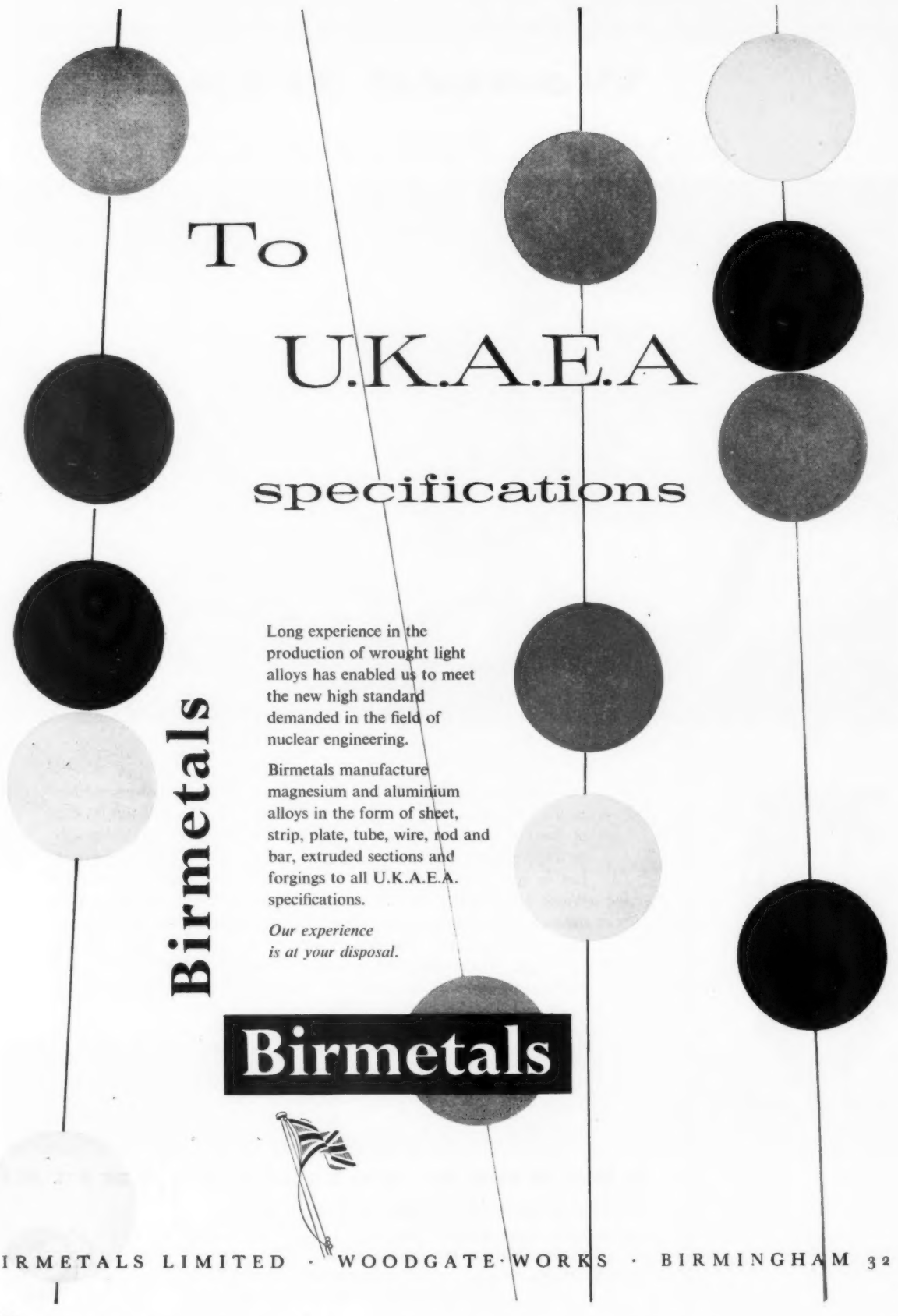
BUTTERS MONOTOWER and DERRICK CRANES were used in the construction of CALDER HALL, CHAPELCROSS, DOUNREAY, HINKLEY POINT, BERKELEY, BRADWELL and HUNTERSTON

On this important undertaking a large number of Butters Derricks were employed, including a heavy 45 ton crane, besides many erection masts and winches.

The crane shown is a 10-ton travelling derrick mounted on 80 ft. towers; the jib is 120 ft. long.

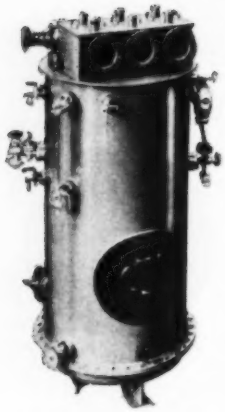
For safe, fast operation with minimum maintenance and low cost of operation the Butters Derrick Crane is unsurpassed.

BUTTERS BROS. & CO. LTD.,
MACLELLAN STREET · GLASGOW, S.1
LONDON: THE CRANE WORKS, LONG LANE, HILLINGDON, MIDDLESEX, and at BIRMINGHAM and NEWCASTLE


To
U.K.A.E.A
specifications
Birmetals
Long experience in the production of wrought light alloys has enabled us to meet the new high standard demanded in the field of nuclear engineering.
Birmetals manufacture magnesium and aluminium alloys in the form of sheet, strip, plate, tube, wire, rod and bar, extruded sections and forgings to all U.K.A.E.A. specifications.
Our experience is at your disposal.
Birmetals
BIRMETALS LIMITED · WOODGATE WORKS · BIRMINGHAM 32

BM 240

Wasted Heat!



A 3 unit Down Flow waste heat boiler

For centuries mankind has dreamed of harnessing the power and heat of the volcano to serve rather than destroy him, but still the wastage of heat continues. Heat Wastage occurs not only in Volcanoes: throughout the World manufacturing plants and ships continue to run in semi-harness, but not Spanner's Clients. They use Spanner Waste Heat Boilers to put to work the heat of exhaust gases from their engines and furnaces with a resultant boost in thermal efficiency. The whole of the Spanner range of boilers has the exclusive "Swirlyflo" tube, designed to extract the maximum heat, and in turn making possible compactness of design with a resultant saving in space.

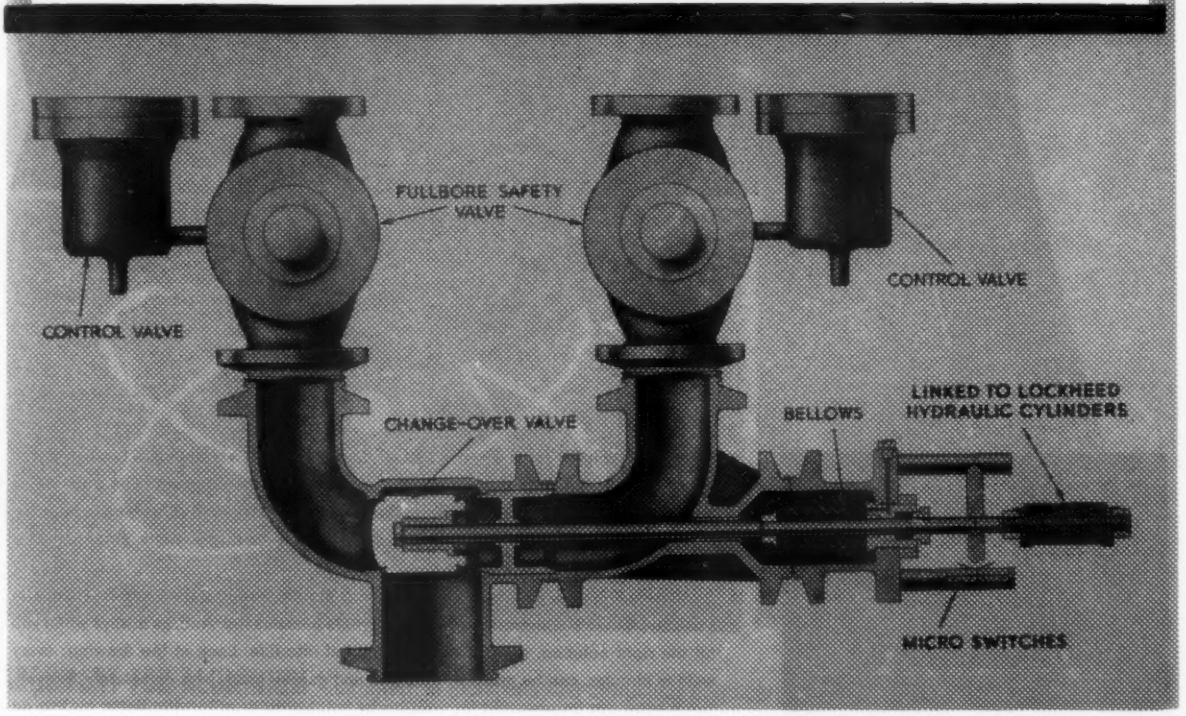
Spanner have the answer to all your waste heat problems.

SPANNER BOILERS LIMITED

WOKINGHAM ROAD · BRACKNELL · BERKS.

TELEPHONE : BRACKNELL 1500
TELEGRAMS : SWIRLYFLO, BRACKNELL, TELEX.
TELEX : 84130

COCKBURNS VALVES
for
NUCLEAR REACTOR SERVICE



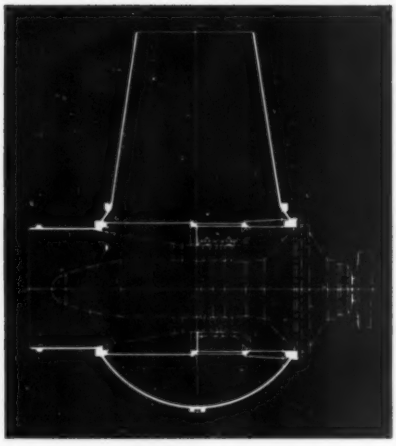
Cockburns are supplying five sets of combined Change-over and Safety Valves for radio active CO_2 gas service in the Advance Gas-cooled Reactor at Windscale.
In selecting Cockburns design Valves for this service the U.K.A.E.A. were drawing on experience of Valve Manufacturing covering almost 100 years.

COCKBURNS VALVES

Cockburns Limited Cardonald Glasgow SW1
London Office: 175 Piccadilly W1
N.E. Depot: Fish Quay N. Shields
COCKBURNS (NEDERLAND) N.V. Kethel Schiedam Holland
COCKBURNS (SPRINGS) LTD Glasgow SW1

Circle **No 94** on reply card for further details

WHY IS A BUBBLE . . OR A WATER DROP SPHERICAL?



"Maximum volume for a given surface" says the bright schoolboy. "Lowest stored energy in the skin for a given internal pressure" says the engineer. The point being that it is the shape which any vessel, subjected to internal pressure, is trying to become. If you insist on any other shape you have to pay for it—in thicker walls, amongst other things.

By making the CO_2 circulator casings for an atomic power station and the bends in the CO_2 pipework spherical, we halved the plate thicknesses. And, as always when you hit the right solution, a lot of other things fell into line. Look at the drawing: every weld is circular, can be made by machine and can be easily and completely X-rayed. Every edge can be prepared for welding by machining or automatic flame cutting on a manipulator.

Fundamentally, good engineering design is just this noticing the obvious (not as easy as it sounds); this questioning; this thinking, not in cliches, not in terms of what is usually, or has always, been done, but about the way things behave; the ringing of every idea against the bedrock of physical laws.

This is what we have to offer at R.W.

RICHARDSONS, WESTGARTH & CO. LTD.

R W G

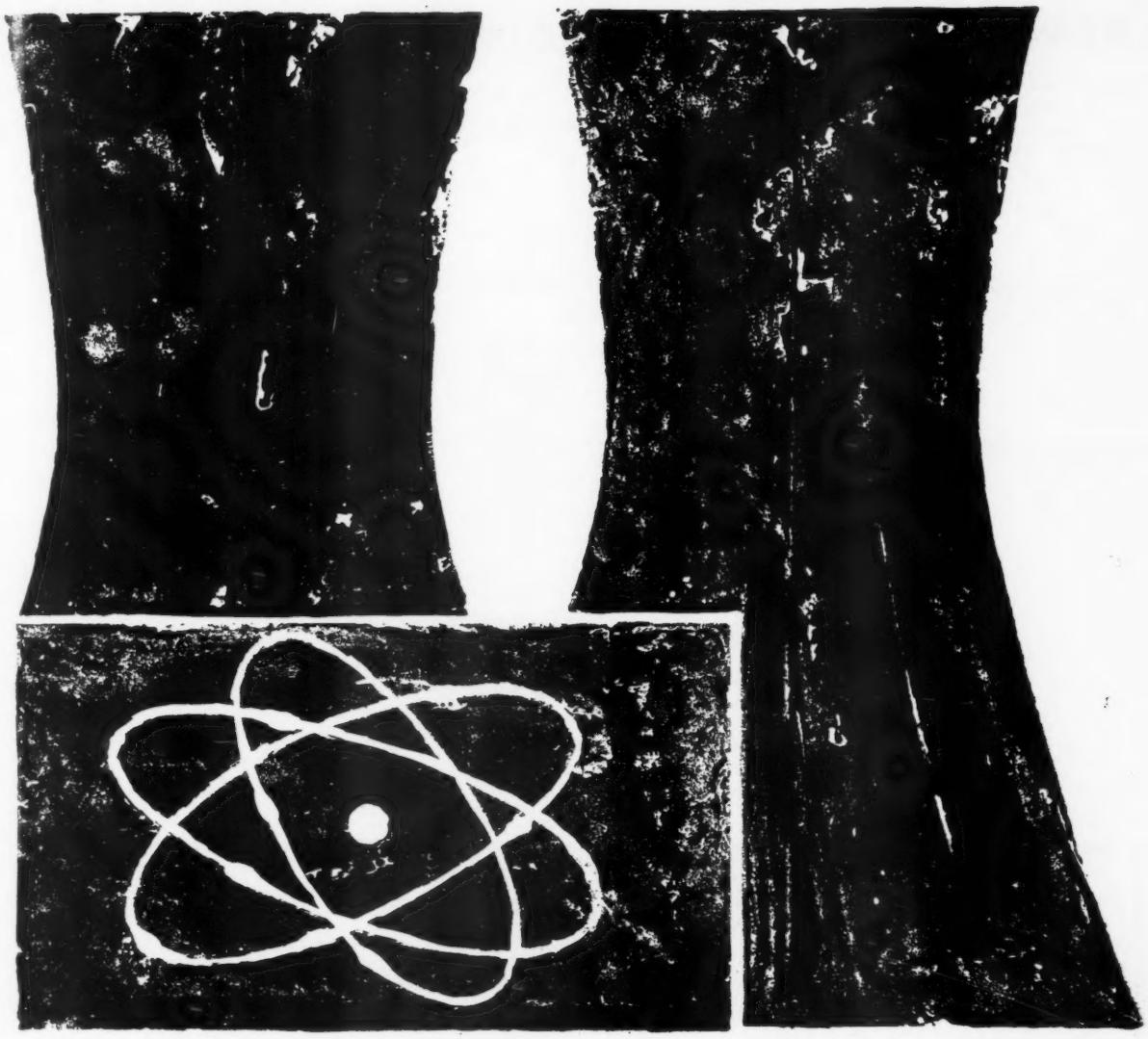
Wallsend, Northumberland, and at 58 Victoria Street, London, S.W.1

The controlling Company of the RICHARDSONS WESTGARTH GROUP, co-ordinating the activities of:—

THE NORTH EASTERN MARINE ENGINEERING CO. LTD.
PARSONS MARINE TURBINE CO. LTD.
GEORGE CLARK (SUNDERLAND) LTD.
RICHARDSONS WESTGARTH (HARTLEPOOL) LTD.
THE HUMBER GRAVING DOCK & ENGINEERING CO. LTD.
RICHARDSONS WESTGARTH ATOMIC LTD.
RICHARDSONS WESTGARTH, INC.

ASSOCIATED COMPANY: ATOMIC POWER CONSTRUCTIONS LTD.

RW52



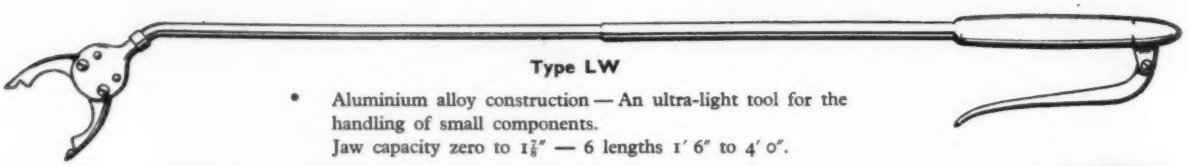
ARGUMENT FOR ALUMINIUM Aluminium is indispensable in nuclear engineering - for cladding reactors, for fabricated pipework and heat exchanger tubes, for such diverse ancillary equipment as glove-boxes, remote control gear and treadplate. **IMPALCO,** backed by ICI and ALCOA, has both the production facilities and the technical know-how to meet the needs of this exacting industry. Wherever there is an argument for aluminium's lightness, durability, good conductivity, ease of handling - contact **IMPALCO** through your nearest ICI Sales Office.

impalco aluminium

Imperial Aluminium Company Limited · Birmingham

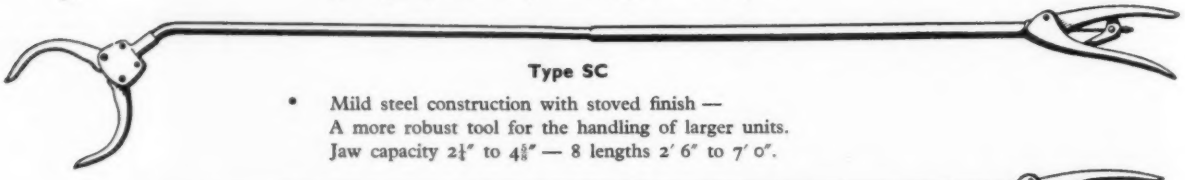
Circle **No 97** on reply card for further details

REMOTE HANDLING TOOLS



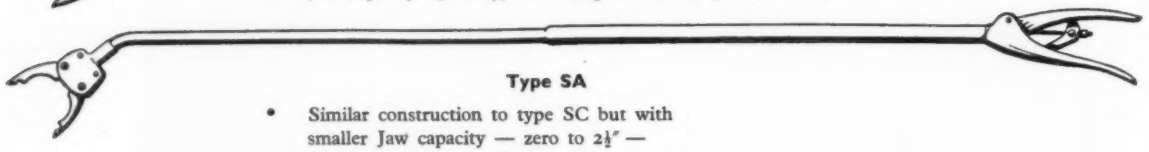
Type LW

- Aluminium alloy construction — An ultra-light tool for the handling of small components.
  Jaw capacity zero to $1\frac{7}{8}$″ — 6 lengths 1′ 6″ to 4′ 0″.



Type SC

- Mild steel construction with stoved finish —
  A more robust tool for the handling of larger units.
  Jaw capacity $2\frac{1}{4}$″ to $4\frac{5}{8}$″ — 8 lengths 2′ 6″ to 7′ 0″.



Type SA

- Similar construction to type SC but with smaller Jaw capacity — zero to $2\frac{1}{2}$″ —
  8 lengths 2′ 6″ to 7′ 0″.
- Types SA and SC manufactured in other lengths to order.

Write for details of our range — or let us know your special requirements

CARTER & VINER · PRESS TOOL ENGINEERS

COODEN SEA ROAD · BEXHILL · SUSSEX · TELEPHONE: COODEN 143

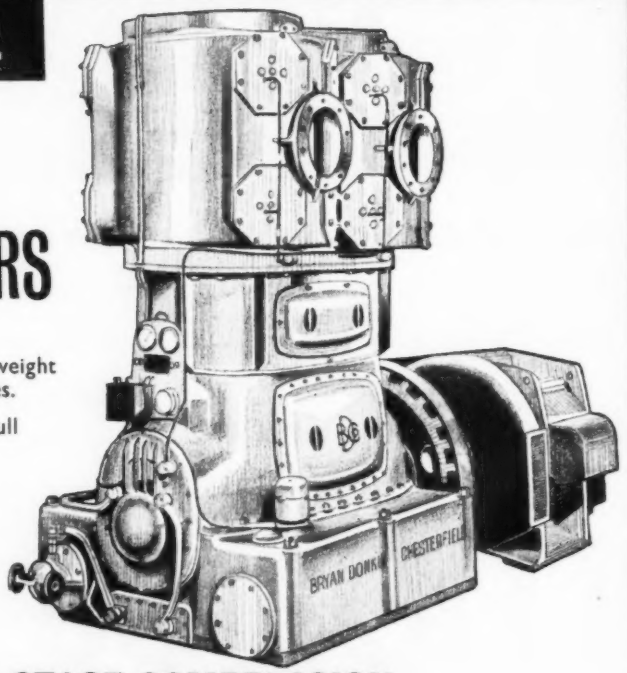
Export enquiries to: — C. Phillips Jones & Co Ltd · Dorchester-on-Thames · Oxford

DONKIN TYPE 300/A.

VERTICAL RECIPROCATING COMPRESSORS

FOR AIR & GASES

- Drop forged connecting rods, give improved weight strength ratio and reduction in unbalanced forces.
- Precision manufactured shell bearings ensure full interchangeability.
- Light alloy frame doors of generous dimension give easy access to interior.
- Centrifugal oil filter and cooler are integral parts of the compressors
- Compressors can be supplied in weather-proof construction for outdoor installation.



FOR SINGLE, TWO OR THREE STAGE COMPRESSION

THE BRYAN DONKIN COMPANY LIMITED TELEPHONE 3153 (6 lines)

CHESTERFIELD · LONDON · TORONTO

RIGHT AT THE CORE

OF ALL

BRITISH REACTORS

Low neutron capture cross section

High apparent density

Good strength

Ease of machining

Nuclear grades of "Acheson" Graphite have now been supplied in considerable tonnages to the United Kingdom Atomic Energy Authority for Calder Hall A and B Reactors, Chapelcross, and for the new Atomic Stations now in construction by the Nuclear Power Consortia Companies. There is no doubt that the very high quality and moderating efficiency of "Acheson" Graphite have been thoroughly proved by full scale performance in present working Reactors.

British Acheson Electrodes Limited, of Grange Mill Lane, Wincobank, Sheffield, have manufactured and supplied more nuclear graphite than all other Companies in the world.

ACHESON

TRADE MARK

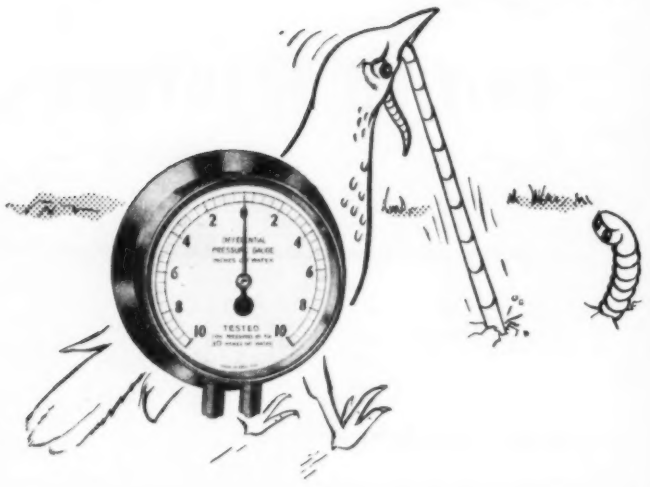
GRAPHITE

The term 'ACHESON' is a registered trade mark

Circle **No 99** on reply card for further details

Circle **No 100** on reply card for further details

The odds are even



That's how it is just now—but, in the end, the thrush has the greater pull and if it were possible to connect their efforts to a P & G differential pressure gauge, the difference would be evident at once.

This P & G pressure gauge finds many applications in industry for measuring pressure differentials and is representative of the many P & G gauges and industrial instruments for special applications.

We shall be pleased to advise on your particular requirements.

Payne & Griffiths Ltd

TUDOR WORKS • WINDMILL LANE
SMETHWICK • BIRMINGHAM

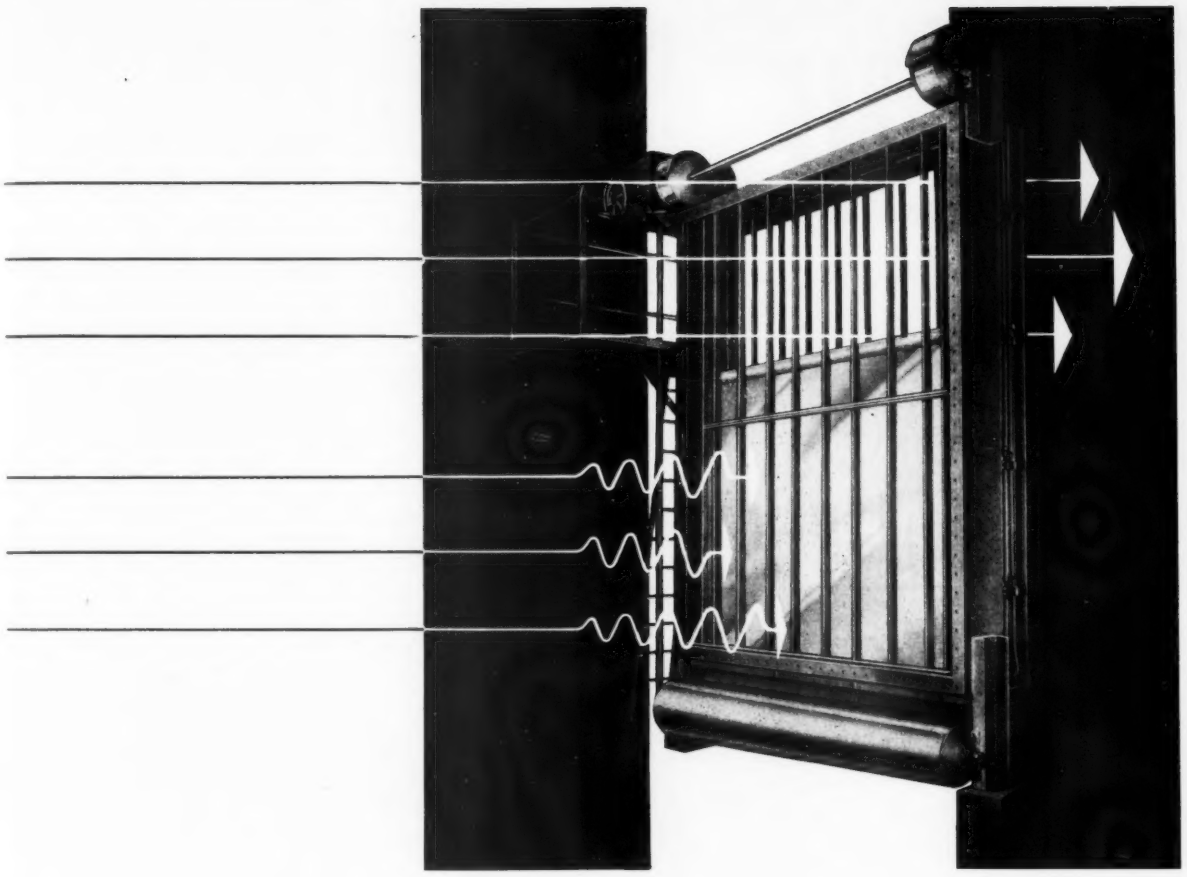
SERVICE IN SEVEN LEAGUE BOOTS For ELECTRONIC COMPONENTS

We produce a comprehensive range of high quality Electronic Components. Consult our Catalogue for your requirements. Our 'By Return' Service will ensure immediate despatch of your orders. Every Component is guaranteed.

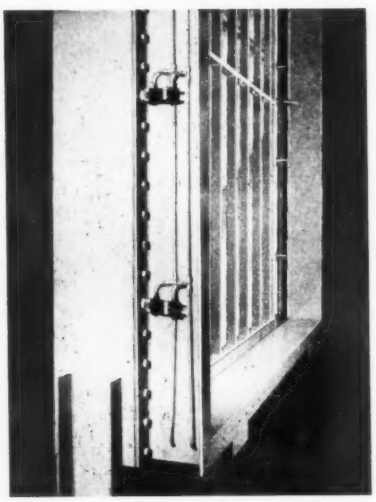
Radiospares Ltd.
4-8 MAPLE STREET • LONDON • W.1 • ENGLAND
Telephone: EUSton 7232-9

TELEGRAMS: RADOSPERES, WESDO, LONDON. *CABLES:* RADOSPERES, LONDON.

Circle **No 101** on reply card for further details



The Dowling Damper



AT LONG LAST . . . A Damper to meet with the conditions in Boiler and Power Station Flues and yet require the minimum of maintenance. The well known difficulties of traditional arrangement are overcome with the Dowling Damper which provides an economical and reliable seal between flue sections of all sizes. It is designed and constructed to withstand varying conditions of temperature, gas pressure, acids and dust that are prevalent in Boiler and Power Station Flues. It can be hand operated or power driven and supplied with air-operated seals if required.

Several large contracts have been successfully negotiated for new Electrical Power Station projects and other applications are being considered daily. Conversions of existing unsuccessful Damper Installations to Dowling-type Installations have also been undertaken with good results.

Enquiries are invited for application in new Power Station projects, Boiler House installations and other applications in the Gas, Chemical, Cement and other industries where the control of hot gas and dust is required in ducting systems and chimneys. Write for fully descriptive leaflet to:

THORNTON

B. Thornton Ltd. Turnbridge Huddersfield Tel: 7541

Circle **No 102** on reply card for further details

MILNE holds the balance

MILNE 'SENSITIVE' REGULATORS

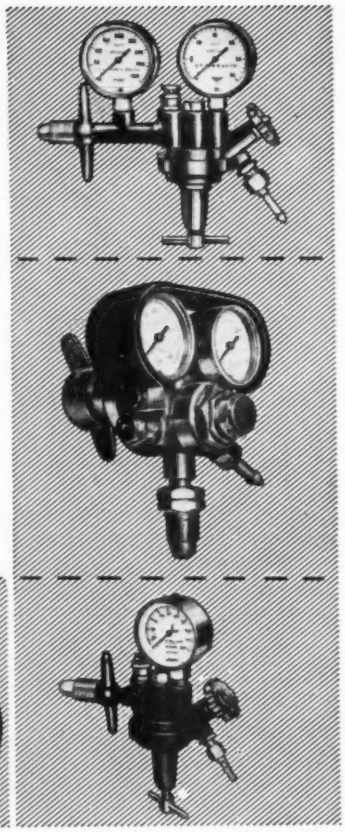
Milne Regulators—robust, highly accurate—designed in a wide variety of patterns to suit every purpose, where oxygen, air, acetylene, propane, coal gas and hydrogen are employed.

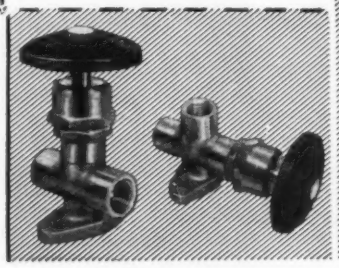
Hexagon or wing nuts can be fitted to any regulator as required.

MILNE BALANCE PRESSURE VALVES

Designed for the job and made to last. Finger-tip control for high and low pressure.

Send for full details





C. S. MILNE & CO. LTD.

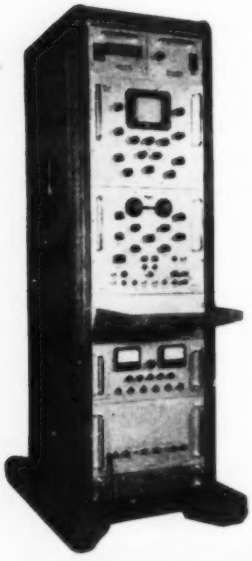
Manufacturers of Gas Welding and Cutting Plant and Equipment. Stockists and Suppliers of Electric Arc and Resistance Welding Equipment.

Harley Works, Octavius Street, Deptford, London, S.E.8

Telephone : Tideway 3852 (4 lines)

Also at 172/174 West Regent Street, Glasgow, C.2.

MARSHALL

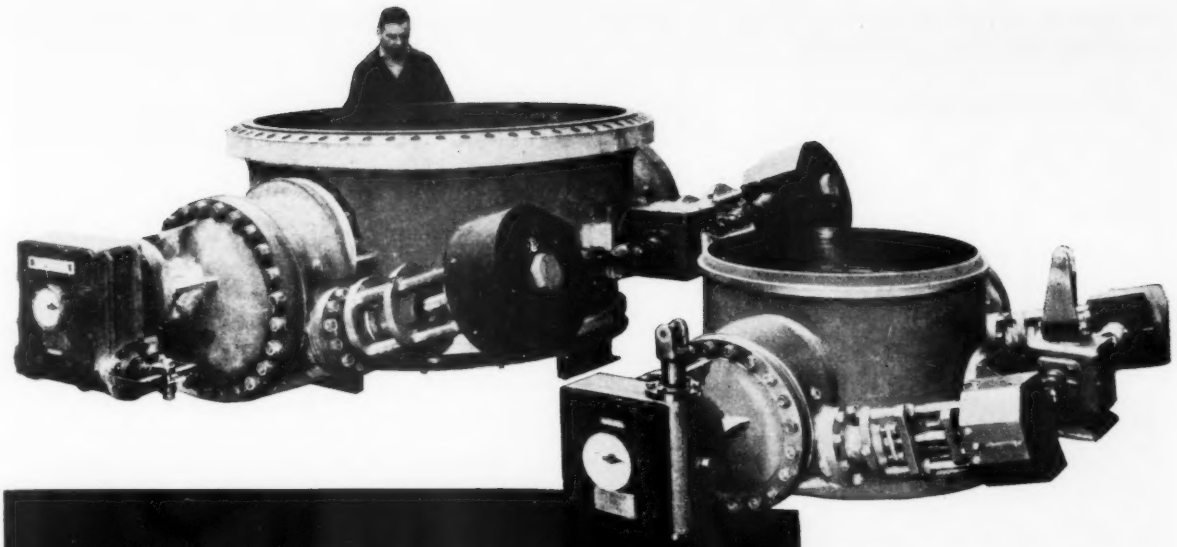


- **PULSE HEIGHT ANALYSER, Type H.S. 100.**
  A sophisticated instrument in the lower price range. Includes Scaler, Live Time Integrator and Print-Out.
- **TWIN-CHANNEL PULSE GENERATORS, Types T.P.G. 100 and T.P.G. 102.**
- **MAGNETIC PULSE RECORDER, Type M.P.R. 103, Transistorised, Printed Circuit.**
- **SCALERS, 1 Mc/s and 10 Mc/s, Types S.200 and S.201, Transistorised, Printed Circuits.**

Enquiries to Sales Department

MARSHALL OF CAMBRIDGE ELECTRONICS LIMITED

THE AIRPORT · CAMBRIDGE · ENGLAND

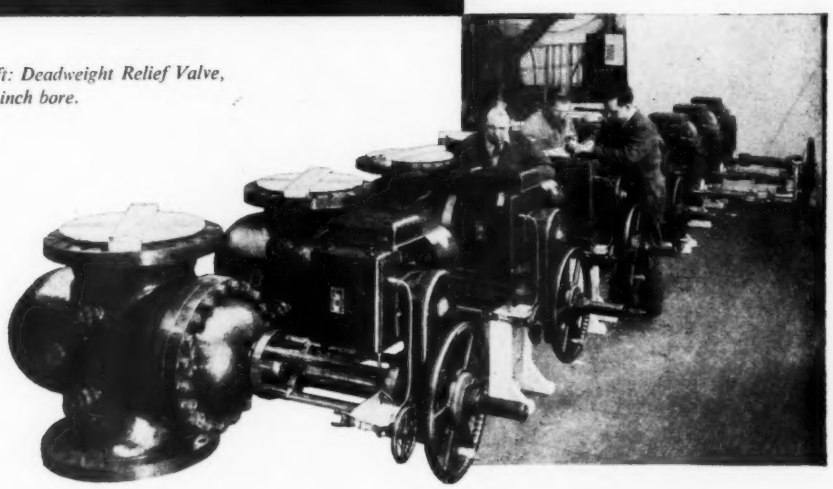


HOPKINSONS' VALVES FOR NUCLEAR POWER STATIONS

Above: "Tansphere" Valves for isolating CO_2 gas between reactor and steam generating plant. Supplied or on order for Bradwell, Hinkley Point, Latina and Trawsfynydd (Valves illustrated are 60 inch and 36 inch bore).

Below: Group of 24 inch electrically - controlled Hopkinson - Ferranti valves for a nuclear power station.

Left: Deadweight Relief Valve, 20 inch bore.



Specialised valves (some of which are illustrated) needed in nuclear power stations are naturally entrusted to Hopkinsons because of their vast experience in the manufacture of valves for exacting duties. But, additionally, Hopkinsons are supplying large numbers of their electrically controlled valves, desuperheating equipment, combined stop and isolating valves, automatic exhaust valves, steam traps and all types and sizes of stop valves.

HOPKINSONS LIMITED · HUDDERSFIELD

LONDON OFFICE: 34 NORFOLK STREET · STRAND · W.C.2

Hopkinsons' valves and fittings have been supplied or are on order for:

Calder Hall
Dounreay
Chapelcross
Berkeley
Hunterston
Bradwell
Hinkley Point
Latina (Italy)
Trawsfynydd

HV121

Circle **No 105** on reply card for further details

Circle **No 106** on reply card for further details

Balteau

INDUSTRIAL X-RAY EQUIPMENT

—always at hand

The well known Pantak range of industrial X-ray equipment has now been augmented to include the completely portable Balteau units manufactured by Usines Balteau of Liege. Backed by the unequalled Pantak after-sales service, these units have been designed to give the maximum number of KV per lb. and are available in three sizes to meet the varying needs of different industries. The Baltospot 140 has an X-ray head of 55 lbs., the 200 has an X-ray head of 84 lbs. and the 300 an X-ray head of 148 lbs. Each of these units can easily be moved by one man.

Please write for full details of Balteau and Pantak equipment up to 500 KV.

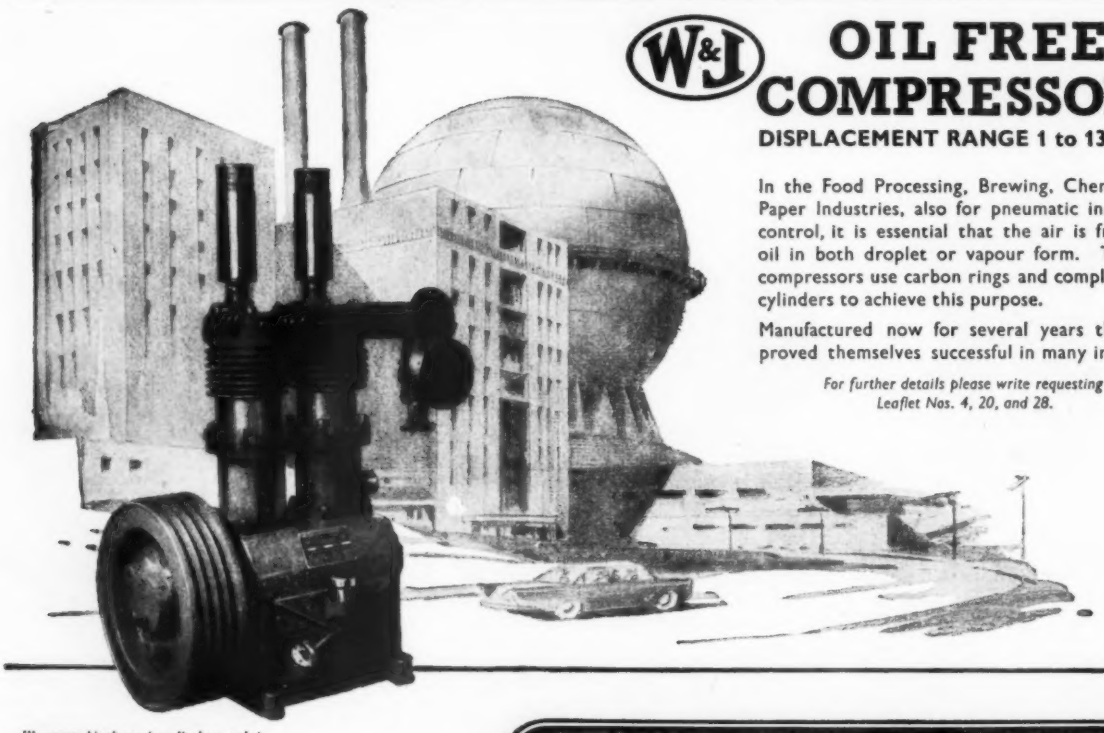
PANTAK LIMITED

VALE ROAD · WINDSOR · BERKS
Telephone : WINDSOR 3225–6

W&J

OIL FREE COMPRESSORS

DISPLACEMENT RANGE 1 to 136 c.f.m.



In the Food Processing, Brewing, Chemical and Paper Industries, also for pneumatic instrument control, it is essential that the air is free from oil in both droplet or vapour form. The W&J compressors use carbon rings and completely dry cylinders to achieve this purpose.

Manufactured now for several years they have proved themselves successful in many industries.

For further details please write requesting Leaflet Nos. 4, 20, and 28.

Illustrated is the twin cylinder model having a free air delivery of 50 c.f.m.

WILLIAMS & JAMES (ENGINEERS) LIMITED
GLOUCESTER · ENGLAND
TELEPHONE: GLOUCESTER 24021-2-3 · TELEGRAMS & CABLES: "COMPRESSOR GLOUCESTER"

Boving

butterfly valves with oleo-pneumatic operation and automatic closing

* Asymmetric design of the blade enables valve to be used as a combined stop and non-return valve. The non-return characteristics are maintained whether or not the control cubicle is in use.
* Blade design simplifies arrangement of the valve seating, contributing considerably to drop-tight sealing.
* Flexible control system — opening and closing times easily varied. Valve can be made to crack open, dispensing with a by-pass valve.
* Control cubicle is weatherproof. Can be used to operate valve by remote control.
* Entire system built up of standard items.

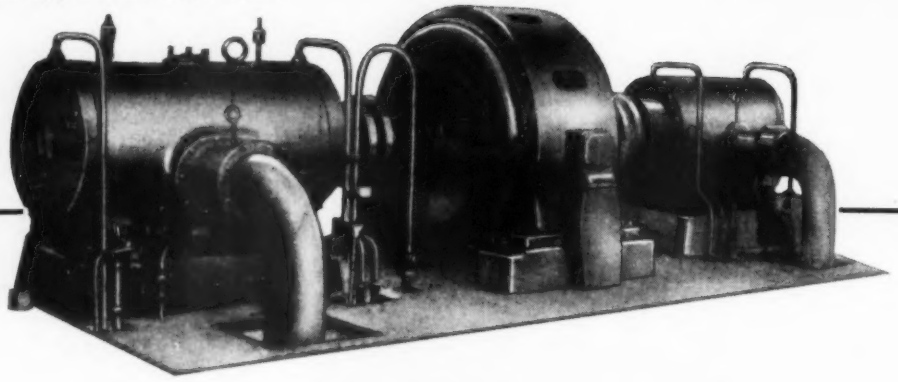
These new butterfly valves maintain Boving's long-established tradition of durability and long-term reliablity.

Please write for descriptive literature

Boving
& CO LIMITED
VILLIERS HOUSE 41-47 STRAND
LONDON WC2

P4988

Circle **No 109** on reply card for further details



HOLLAND-S. L. M.

ROTARY COMPRESSORS AND VACUUM PUMPS

SUPPLIED FOR: **HARWELL, WINFRITH, BERKELEY**

The B. A. Holland Engineering Co. Ltd.

LINDO LODGE, STANLEY AVENUE, CHESHAM, BUCKS.

Telephone: Chesham 8406/8 **Telegrams: Picturable Chesham** **Works: SLOUGH, BUCKS**

industries atomiques

The international review for the peaceful uses of nuclear energy
A RENE KISTER PUBLICATION

Annual Subscription

12 numbers per year	
French new francs	41,50
Belgian francs	510
Swiss francs	40
German marks	40
U.S. dollars	10
Pounds sterling	3/15/0

INDUSTRIES ATOMIQUES

is the only international technical and industrial review printed in French, which specialises entirely in nuclear and related subjects.

INDUSTRIES ATOMIQUES is read by industrialists, engineers, technicians and chemists, heads of technical firms and by all those engaged in the world of science. In short, it is intended expressly for all specialists interested in research and in its practical realisation.

In view of its international character, INDUSTRIES ATOMIQUES is read and appreciated in countries all over the world.

Up to date, more than 250 authors, all specialists, have honoured this review with their collaboration, and have contributed **previously unpublished** articles of high scientific value, abundantly illustrated.

INDUSTRIES ATOMIQUES is a source of precise documentation, constantly being brought up to date. The international information and the list of suppliers to the atomic industries printed in its pages will be found invaluable.

Industries Atomiques Subscription form

Subscriptions can be paid in the currency of the country at any European post office.

We desire _____ **annual subscriptions, starting from** _____ **, to be sent to (surname, Christian names, or firm's name, and address)** _____

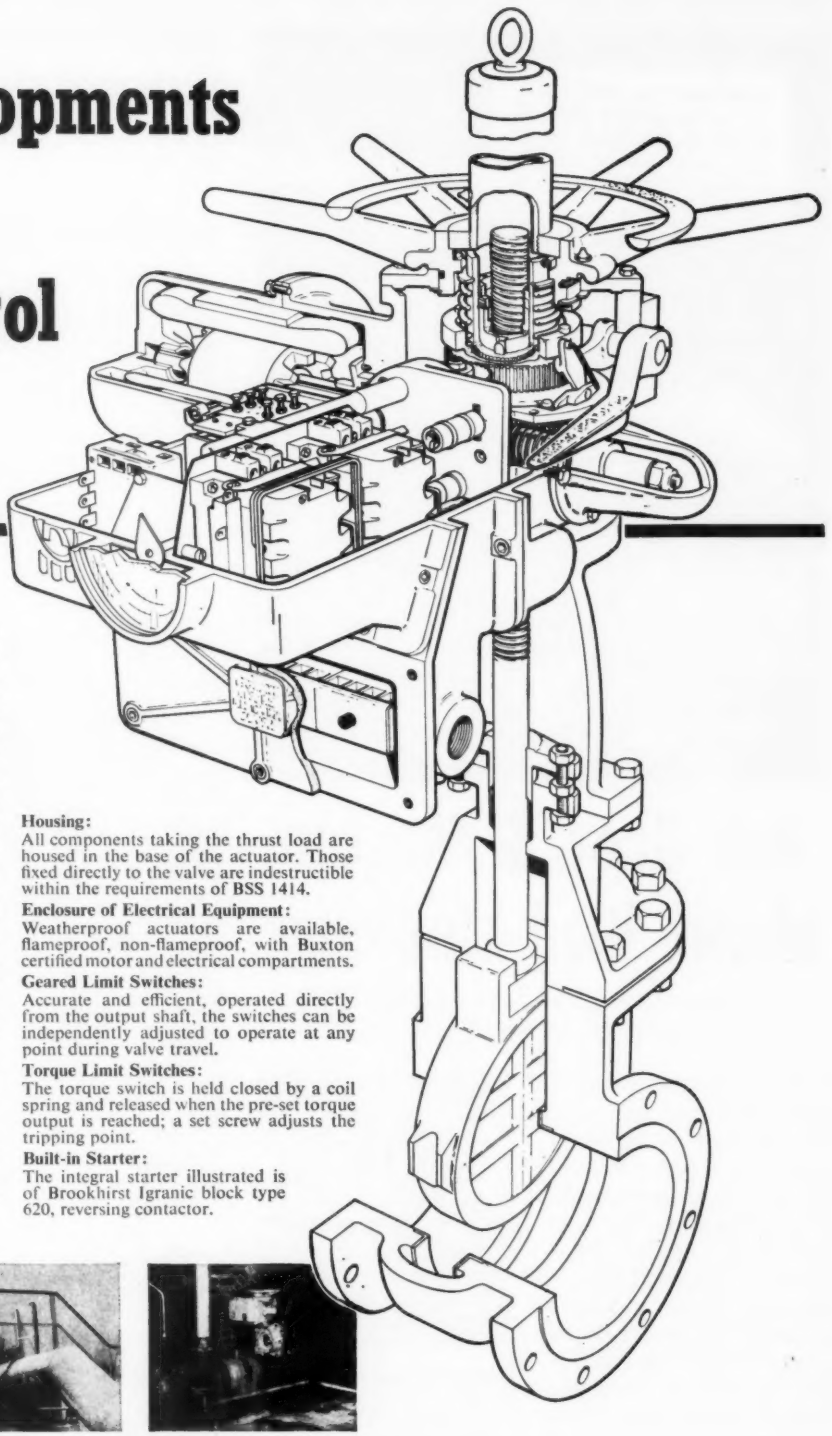
_____

Method of payment _____ **Date and signature:**

_____

(This form should be returned in a stamped and addressed envelope to NUCLEAR POWER, 77-79 Charlotte Street, London, W1.)

New developments in Rotork valve control



Valve manufacturers and users all over the world have helped Rotork develop their new series of electric actuators — the 'A' range. Such practical advice, coupled with Rotork's comprehensive experience of valve control, ensures that the 'A' range offers the most competent method available for automatically controlling any size or type of valve from any distance.

An entirely new manufacturing and selling organisation has been created to keep pace with the growing international demand for Rotork actuators. Highly competitive prices and good deliveries on a world-wide scale are assured by the overseas manufacturing and sales facilities now available in West Germany, France and Italy to augment U.K. production; as well as offices or agents in Holland, Switzerland, Australia, Canada and the Arabian Gulf.

A booklet covering every aspect of the Rotork 'A' range of actuators is available on request.

Outstanding features of the Top Handwheel 'A' Type Actuator illustrated are:—

Motor:
Squirrel cage, Stator/rotor unit, half hour rated and built to BSS 2613. Available with class 'A', 'B' or 'E' insulation.

Input Shaft:
Motor, worm and torque measuring spring pack are all on this common shaft, which slides in direct proportion to the torque transmitted to operate the torque switch to shut off the motor.

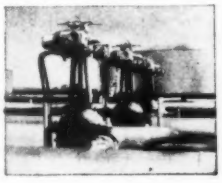
Housing:
All components taking the thrust load are housed in the base of the actuator. Those fixed directly to the valve are indestructible within the requirements of BSS 1414.

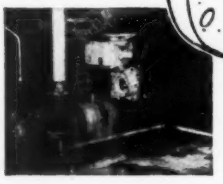
Enclosure of Electrical Equipment:
Weatherproof actuators are available, flameproof, non-flameproof, with Buxton certified motor and electrical compartments.

Geared Limit Switches:
Accurate and efficient, operated directly from the output shaft, the switches can be independently adjusted to operate at any point during valve travel.

Torque Limit Switches:
The torque switch is held closed by a coil spring and released when the pre-set torque output is reached; a set screw adjusts the tripping point.

Built-in Starter:
The integral starter illustrated is of Brookhirst Igranic block type 620, reversing contactor.

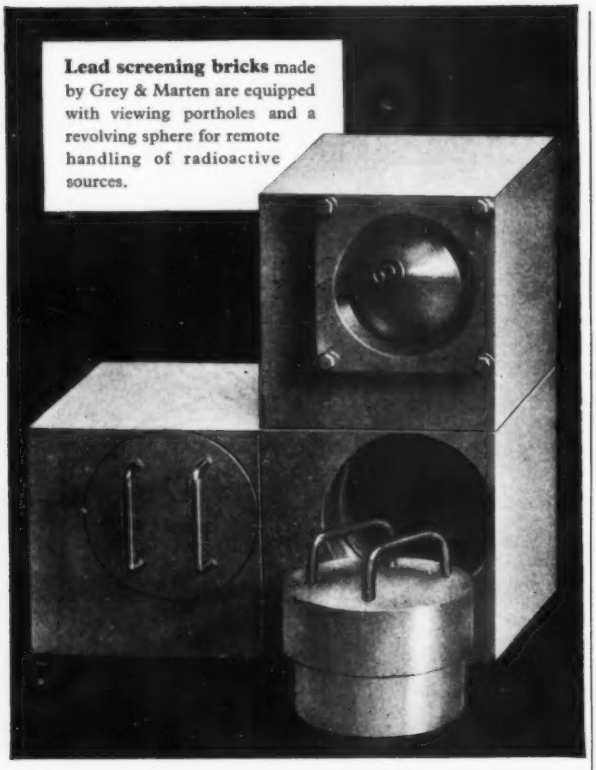




(Left and centre) Two typical overseas petroleum installations using Rotork actuators. (Right) Rotork actuators installed at the Vickers-Armstrong Hydraulic Test Plant.

Rotork have a controlling interest in all types of valves!

ROTORK ENGINEERING COMPANY LIMITED of BATH, ENGLAND. Tel: 64558

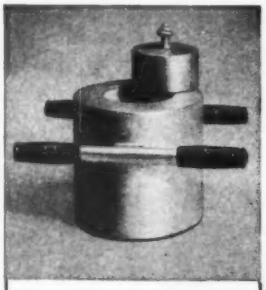


Lead screening bricks made by Grey & Marten are equipped with viewing portholes and a revolving sphere for remote handling of radioactive sources.

Ask Grey & Marten about lead shielding

(Their new subsidiary, James Girdler & Co., has all their skill and experience)

GREY & MARTEN are experts in lead. They've specialised in the manufacture of *all* kinds of lead castings, fabrications and fillings for more than a century. Interlocking Lead Bricks (in one, two and four-inch thicknesses), Lead Sphere Units (in two and four-inch bricks), Aperture and Viewing Bricks, Lead Pots and Isotope Carriers are all produced under the Grey & Marten name. Now they have handed over this activity to their new subsidiary, James Girdler & Co. Ltd.



Storage pot typical of those used in standard safes not already fitted with lead protection, affords economical storage for radio-active material.

GREY & MARTEN LTD

Established 1833

CITY LEAD WORKS, SOUTHWARK BRIDGE, S.E.1
and at Birmingham, Manchester and Ipswich

JAMES GIRDLER & CO. LTD

Mansell Works, Mansell Road, London W.3 CHISWICK 5991

DONCASTERS ◇
1778 D D

Famous for Forgings

The Daniel Doncaster companies have works in Sheffield, Leeds, Oldham and Blaenavon, S. Wales. These works have kept abreast of modern forging practice and new equipment is still being installed on a considerable scale.

More important to you is the *range* of this equipment, for by using a combination of plant and skills, we can offer a service and carry out procedures impracticable to a firm possessing a less versatile organisation.

DANIEL DONCASTER & SONS LIMITED SHEFFIELD

MONK BRIDGE IRON & STEEL CO. LEEDS 12
MOORSIDE COMPONENTS · OLDHAM
DANIEL DONCASTER & SONS (THE BLAENAVON CO. BRANCH) LTD.
BLAENAVON · MONMOUTHSHIRE

STAINLESS STEEL FABRICATIONS
by the specialists

- ★ **Pressure Vessels all classes**
- ★ **Vessels for storage and transport**
- ★ **Condensers and Heat-Exchangers**
- ★ **Pipework and Pipefittings**
- ★ **Laboratory Equipment and Holloware**
- ★ **Ducting and other stainless steel sheet metal work**
- ★ **X-ray weld inspection**

A 200 gallon stainless steel reaction vessel with coil jacket suitable for high pressure steam

As specialists in the manufacture of stainless steel products for 30 years, we have exceptional knowledge of the material. Our staff are skilled in the design of equipment in this metal and our work people in its manipulation. You can therefore place your requirements in no better hands.

THE TAYLOR RUSTLESS FITTINGS Co. Ltd.

Head Office: Ring Rd., Lower Wortley, Leeds, 12. *Telephone:* Leeds 638711 PBX
London Office: 14 Great Peter Street, London, S.W.1. *Telephone:* Abbey 1575

Circle **No 114** on reply card for further details

Circle **No 115** on reply card for further details

The Airhydropump portable and mobile units give Hydraulic Pressure where you want it

Several forms of Mobile or Portable Units are available for producing Hydraulic Pressure in remote parts of ships under construction or extensive factories where it is impossible to bring the equipment to be tested to a static test point. The illustration shows a Standard Airhydropump mounted on a trolley complete with 5 gallon reservoir, control valves and gauges.

The Portable Unit incorporating the Junior Airhydropump is fitted in a glass fibre case—total weight 40 lb. The lid of the case is reversed to form a 5 gallon reservoir. The air supply can be obtained from a bottle if there is no air line available.

CM19

Send for Brochure PORT 1/11

CHARLES S. MADAN & CO. LIMITED
VORTEX WORKS · ALTRINCHAM · CHESHIRE

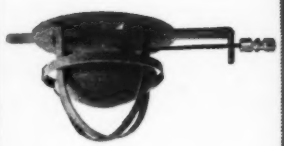
Tel: ALTRINCHAM 2702 Grams: VORTEX ALTRINCHAM (Telex) TELEX 66-105 A/B ATLANTIC ALTCHM.

CONSTANT GUARD AGAINST ONE OF THE NATION'S MOST DEADLY AND DESTRUCTIVE ENEMIES

Specially selected for day-and-night duty at the Dounreay Works—U.K. Experimental Reactor Establishment—Kidde's pneumatic 'rate of rise' system ensures earliest possible warning of fire . . . *in fire conditions the alarm is given in under seven seconds!*

Efficient, highly sensitive, this Kidde heat-actuated fire detector, comprises a copper chamber, which—at the slightest rise in temperature—undergoes a corresponding increase in air pressure.

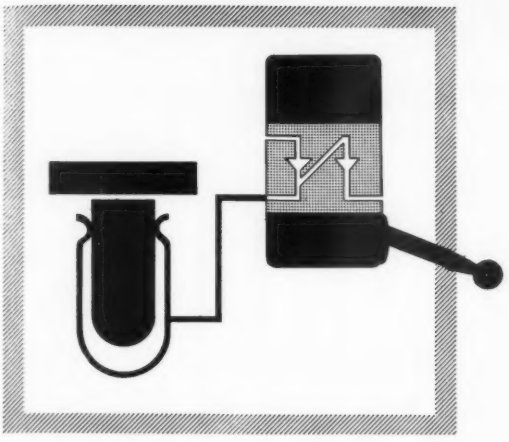
No false alarms though! The detector's carefully calibrated vent compensates for normal pressure variations (i.e. weather and interior heating). In virtually all other U.K. Atomic Energy Centres, as at Dounreay, Kidde fire protection equipment is safe-guarding life, vital apparatus and processes . . . make sure your interests are well-protected. Walter Kidde are specialists in inert gas extinguishing equipment employing carbon dioxide, argon, nitrogen CF_3BR, products of combustion, and have a range of over twelve different detectors, each specifically suited to meet a particular requirement.



K Kidde

THE WALTER KIDDE CO. LTD.,
Northolt, Middlesex. Tel: VIKing 6611

Circle **No 116** on reply card for further details



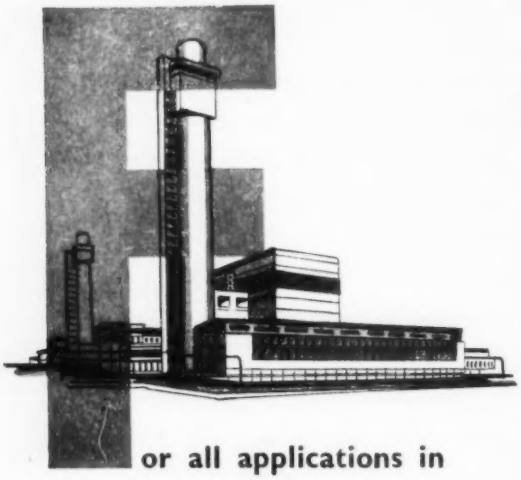
Ellison Valves are available for most forms of hydraulic control from the simplest, as illustrated, to complicated forms of automatic control using timing devices.
The illustration below shows a valve for A.C. solenoid operation. Two A.C. or D.C. solenoids may be provided, if required, to give a "Neutral" position.
The valve is easily converted for operation by hand, foot, air-cylinder or hydraulic cylinder.

the ELLISON EC Mark II valve — Solenoid Operation

GEORGE ELLISON LIMITED (HYDRAULICS DIVISION) • PERRY BARR • BIRMINGHAM 22B

104

Circle **No 118** on reply card for further details



or all applications in
Nuclear Power plants . . .
. . . continue to fit

FREMO STAINLESS STEEL

bolts, nuts, screws
and other fasteners
with corrosion,
contamination and
heat resistant
properties.

FREMO
TRADE MARK

FREDERICK MOUNTFORD
(BIRMINGHAM) **LIMITED**
Fremo Works, Moseley St., Birmingham, 5
Tel. MIDland 7984 PBX
Grams 'FREMO' Birmingham

Circle **No 119** on reply card for further details

Stockholders of

STAINLESS STEEL

SHEETS · BARS · PLATES
STRIPS & BLANKS

PROFILE CUTTING &
SHEET POLISHING

C&D
COX AND DANKS
LIMITED

PROFILE CUTTING
TO ANY SHAPE

SCAPA HOUSE · PARK ROYAL RD.
LONDON N.W.10

Tel: Elgar 5811 Telex 25239

A METAL INDUSTRIES GROUP COMPANY

SERVICE DE RENSEIGNEMENTS POUR NOS LECTEURS

Il est souvent difficile au client publicitaire d'indiquer dans un espace restreint tous les détails de ses produits. Dans le cas où vous désireriez de plus amples renseignements à ce sujet, veuillez pointer le numéro approprié sur la carte ci-contre et envoyer cette dernière à NUCLEAR POWER

AUSKUNFTSDIENST FÜR LESER

Es ist oft schwierig für Inserenten alle technischen Einzelheiten über ihre Produkte in einem begrenzten Platz zu bringen. Sollten Sie noch weitere Auskünfte wünschen, streichen Sie einfach die bestimmten Nummern auf der nebenstehenden Karte an, und senden Sie sie an NUCLEAR POWER

SERVIZIO D'INFORMAZIONI PER I NOSTRI LETTORI

E' talvolta difficile all'inserzionista di indicare in uno spazio ristretto tutti i particolari dei suoi prodotti. Qualora desideraste ricevere più ampie informazioni a questo riguardo, favorite segnare il numero appropriato sul cartellino qui accanto ed inviare quest'ultimo a NUCLEAR POWER

SERVICIO DE INFORMACIÓN PARA EL LECTOR

Se hace a menudo difícil para los anunciantes dar en un espacio limitado todos los detalles técnicos sobre sus productos. Si desea ulterior información, marque los números apropiados en la tarjeta opuesta y mándela a NUCLEAR POWER

Информация для читателей

Часто бывает трудно рекламирующим лицам давать все технические подробности своей продукции в рекламе. Если Вам понадобятся добавочные сведения, то просто отметьте соответствующие номера на наточке на противоположной стороне и отправьте к NUCLEAR POWER

讀者訊問服務

在廣告上以有限的地方來解釋一些專門技術及它們的効果，的確是有受限制的困难。若貴欢看知道一些詳細的情形就請將对貴的表格取一號下來對閱下有疑問的項目，同笔勾一下即寄様子能工經意即可。

讀者サービス

廣告紙面の関係上製品の技術的細目は掲載しきれませんので詳しくは貴のカードの適當なナンバーに印をつけて原子力現設計して下さればお答へします。

Nuclear Power

REACTORS MATERIALS INSTRUMENTATION PROCESSES IRRADIATION

READER INFORMATION SERVICE September 1960

Advertisements

1	24	47	70	93	116	139	162	185
2	25	48	71	94	117	140	163	186
3	26	49	72	95	118	141	164	187
4	27	50	73	96	119	142	165	188
5	28	51	74	97	120	143	166	189
6	29	52	75	98	121	144	167	190
7	30	53	76	99	122	145	168	191
8	31	54	77	100	123	146	169	192
9	32	55	78	101	124	147	170	193
10	33	56	79	102	125	148	171	194
11	34	57	80	103	126	149	172	195
12	35	58	81	104	127	150	173	196
13	36	59	82	105	128	151	174	197
14	37	60	83	106	129	152	175	198
15	38	61	84	107	130	153	176	199
16	39	62	85	108	131	154	177	200
17	40	63	86	109	132	155	178	201
18	41	64	87	110	133	156	179	202
19	42	65	88	111	134	157	180	203
20	43	66	89	112	135	158	181	204
21	44	67	90	113	136	159	182	205
22	45	68	91	114	137	160	183	206
23	46	69	92	115	138	161	184	207

New Products and Ind. Literature

208	214	220	226	232	238	244	250	256
209	215	221	227	233	239	245	251	257
210	216	222	228	234	240	246	252	258
211	217	223	229	235	241	247	253	259
212	218	224	230	236	242	248	254	260
213	219	225	231	237	243	249	255	261

Books

262	264	266	268	270	272	274	276	278
263	265	267	269	271	273	275	277	279

If you would like further information about any advertisement or editorial item, simply circle the appropriate numbers on this card and mail to NUCLEAR POWER.

NAME

NAME OF BUSINESS

ADDRESS

POSITION HELD

NATURE OF BUSINESS

Nuclear Power

REACTORS MATERIALS INSTRUMENTATION PROCESSES IRRADIATION

READER INFORMATION SERVICE September 1960

Advertisements

1	24	47	70	93	116	139	162	185
2	25	48	71	94	117	140	163	186
3	26	49	72	95	118	141	164	187
4	27	50	73	96	119	142	165	188
5	28	51	74	97	120	143	166	189
6	29	52	75	98	121	144	167	190
7	30	53	76	99	122	145	168	191
8	31	54	77	100	123	146	169	192
9	32	55	78	101	124	147	170	193
10	33	56	79	102	125	148	171	194
11	34	57	80	103	126	149	172	195
12	35	58	81	104	127	150	173	196
13	36	59	82	105	128	151	174	197
14	37	60	83	106	129	152	175	198
15	38	61	84	107	130	153	176	199
16	39	62	85	108	131	154	177	200
17	40	63	86	109	132	155	178	201
18	41	64	87	110	133	156	179	202
19	42	65	88	111	134	157	180	203
20	43	66	89	112	135	158	181	204
21	44	67	90	113	136	159	182	205
22	45	68	91	114	137	160	183	206
23	46	69	92	115	138	161	184	207

New Products and Ind. Literature

208	214	220	226	232	238	244	250	256
209	215	221	227	233	239	245	251	257
210	216	222	228	234	240	246	252	258
211	217	223	229	235	241	247	253	259
212	218	224	230	236	242	248	254	260
213	219	225	231	237	243	249	255	261

Books

262	264	266	268	270	272	274	276	278
263	265	267	269	271	273	275	277	279

If you would like further information about any advertisement or editorial item, simply circle the appropriate numbers on this card and mail to NUCLEAR POWER.

NAME

NAME OF BUSINESS

ADDRESS

POSITION HELD

NATURE OF BUSINESS

Nuclear Power

REACTORS MATERIALS INSTRUMENTATION PROCESSES IRRADIATION

READER INFORMATION SERVICE September 1960

Advertisements

1	24	47	70	93	116	139	162	185
2	25	48	71	94	117	140	163	186
3	26	49	72	95	118	141	164	187
4	27	50	73	96	119	142	165	188
5	28	51	74	97	120	143	166	189
6	29	52	75	98	121	144	167	190
7	30	53	76	99	122	145	168	191
8	31	54	77	100	123	146	169	192
9	32	55	78	101	124	147	170	193
10	33	56	79	102	125	148	171	194
11	34	57	80	103	126	149	172	195
12	35	58	81	104	127	150	173	196
13	36	59	82	105	128	151	174	197
14	37	60	83	106	129	152	175	198
15	38	61	84	107	130	153	176	199
16	39	62	85	108	131	154	177	200
17	40	63	86	109	132	155	178	201
18	41	64	87	110	133	156	179	202
19	42	65	88	111	134	157	180	203
20	43	66	89	112	135	158	181	204
21	44	67	90	113	136	159	182	205
22	45	68	91	114	137	160	183	206
23	46	69	92	115	138	161	184	207

New Products and Ind. Literature

208	214	220	226	232	238	244	250	256
209	215	221	227	233	239	245	251	257
210	216	222	228	234	240	246	252	258
211	217	223	229	235	241	247	253	259
212	218	224	230	236	242	248	254	260
213	219	225	231	237	243	249	255	261

Books

If you would like further information about any advertisement or editorial item, simply circle the appropriate numbers on this card and mail to NUCLEAR POWER.

NAME

NAME OF BUSINESS

ADDRESS

POSITION HELD

NATURE OF BUSINESS

Postage will be paid by Nuclear Power

No Postage stamp necessary if posted in Great Britain or Northern Ireland

Business Reply Folder Licence WD 1823

NUCLEAR POWER
Rowse Muir Publications Ltd,
The Rowse Muir Building,
77–79 Charlotte Street,
London, W1
England

Postage will be paid by Nuclear Power

No Postage stamp necessary if posted in Great Britain or Northern Ireland

Business Reply Folder Licence WD 1823

NUCLEAR POWER
Rowse Muir Publications Ltd,
The Rowse Muir Building,
77–79 Charlotte Street,
London, W1
England

Postage will be paid by Nuclear Power

No Postage stamp necessary if posted in Great Britain or Northern Ireland

Business Reply Folder Licence WD 1823

NUCLEAR POWER
Rowse Muir Publications Ltd,
The Rowse Muir Building,
77–79 Charlotte Street,
London, W1
England

the Rocol technical information service

Brochures dealing with

SPECIALISED LUBRICANTS

for industry

wdh i0683/A

Engineering and other industrial firms are offered the following, as one aspect of ROCOL *service.*

Publication No. 1. **ANTI-SCUFFING PASTE AND OIL**
Anti-Scuffing Paste is the most effective means of applying Molybdenum Disulphide for dry lubrication. Used where ordinary oils and greases cannot be applied. Withstands immense heat and pressure, and has remarkable anti-seize properties. Approved under D.T.D. 900/4284. Anti-Scuffing Oil enables Molybdenum Disulphide to be used in circulating systems and oil lubricators.

Publication No. 2. **R.T.D. COMPOUND**
The modern lubricant for severe metal forming and shaping operations. Counters the effects of high pressure and eliminates frictional heat in drilling, reaming and tapping stainless steel, alloy steels, nickel and titanium. Can lengthen tool life by as much as 30 times.

Publication No. 3. **MOLYBDENISED LUBRICANTS**
The remarkable low friction and pressure resisting properties of Molybdenum Disulphide have been incorporated in a wide range of specialised lubricants, compounds and varnishes described in this Brochure.

Publication No. 4. **WATCH AND CLOCK OILS**
A complete range for the Horological and Instrument Engineer, based on joint research of horologists and oil technicians. Includes a range of synthetic oils which remains fluid down to minus 65°C; and Molybdenised Oils in all viscosities.

Publication No. 5. **KILOPOISE LUBRICANTS**
Extreme-viscosity lubricants to damp motion and ensure a slow, even action in hand operated components such as optical focusing movements, variable condensers and potentiometer spindles. Widely used throughout the optical, instrument, radio and electronic industries. Special grades available for use as Core Locking Compounds.

Publication No. 8. **MOLYTONE GREASE**
A series of greases combining Rocol Bentone Grease and Molybdenum Disulphide. They have no melting point and are effective from below zero to 450°F. They withstand extreme pressures and provide positive lubrication even in 'starved' conditions. They should be used in all grease systems where extra boundary lubrication is demanded by severe working conditions.

Write to ROCOL *about lubrication.*

ROCOL LIMITED

General Buildings, Aldwych, London, W.C.2 (*Telephone:* HOLborn 1985)
Rocol House, Swillington, nr. Leeds. (*Telephone:* Garforth 2261)

Circle **No 121** on reply card for further details

PROBLEM SOLUTION

Sequence pumping is occasionally required in a hand-operated pumping plant which, although intended to be used spasmodically, must also be guarded against failure of water supply. Other pre-requisites are rough and fine pumping; isolation and air admittance.

the answer came from —

N·G·N

Rotary pumps, diffusion pumps, valves, combined units—these are but a few from the very full range of equipment now being produced for the High Vacuum industry by N.G.N.....our technical services are being increasingly used to assist and advise on problems of High Vacuum. Why not make use of them—NOW.

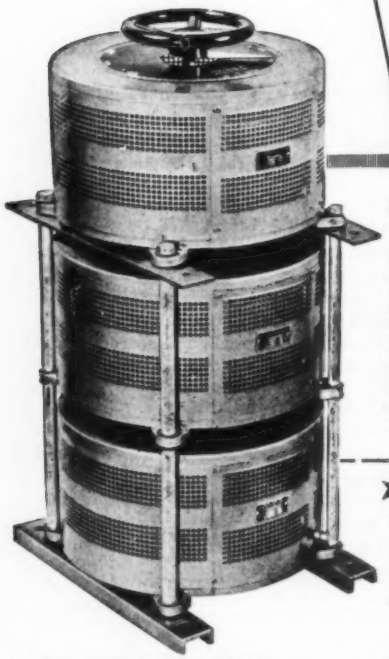
Type HCU Pumping Plant

By means of the two hand valves used in conjunction with the baffle valve, sequence pumping may be obtained when using the Type HCU Pumping Plant which is equipped to give Rough Pumping and Fine Pumping, isolation or Air Admittance, and water relay to protect the Diffusion Pump against water supply failure. In general, the HCU is more suitable where access to the vacuum chamber is not required for production sequence cycles, and where the plant is not likely to be left running overnight without supervision.

N.G.N. FOR HIGH VACUUM

High Vacuum Specialists and Electrical Engineers

N.G.N. ELECTRICAL LIMITED
Avenue Parade, Accrington, Lancs.
Telephone: Accrington 35611-2



This 3-gang assembly, Type 50-BMG3, will control 22·5kVA, 3-phase or single-phase according to connection. Larger assemblies can be made.

Variac WITH Duratrak ☆

Regd. Trademark

THE MOST USEFUL DEVICE KNOWN FOR THE CONTROL OF AC VOLTAGE

VARIAC is the original continuously-adjustable auto-transformer, providing a smoothly variable output from zero to line voltage and above.
VARIACS are available in a very wide range of models from small units for laboratory and instrument use to large ganged assemblies for three-phase power.
VARIACS are available open or covered, as single units or ganged assemblies, for manual operation or motor-driven.

The range includes portable, metalclad and oil-immersed models, dual-output types, high-frequency types and many 'specials'. *Write for complete information.*

☆ **Duratrak?** Duratrak (Regd. Trademark) —a patented* feature exclusive to Variac—is a special plated contact surface giving longer life, increased overload and surge capacity and maximum economy in maintenance. Duratrak is now standard on all models except Series 50.

**U.K. Pat. No. 693406*

ONLY VARIAC HAS DURATRAK

This small Variac, Type V-5HMTF, provides an output of 0-270 V, 2 A, from 240 V 50 c/s mains. A still smaller model. Type V-3H is rated at 1 A.

Claude Lyons Ltd.

VALLEY WORKS · HODDESDON · HERTS · TEL: HODDESDON 4541-6

and 76 Old Hall Street · Liverpool 3 · Tel: CENtral 4641-2

CL 59/2B

You can build any design of case, rack, console or cabinet you like, in any quantity you like, or have them built quickly for you—Imhof's new IMLOK Manual tells you how! 42 pages with full colour illustrations give the whole story: show *every* connector and extrusion in detail: explain exactly what each is used for: give simple step-by-step instructions on how to make IMLOK frameworks, how to fit panels. The IMLOK Manual guides you in designing and using IMLOK and gives a wide range of examples—*which have all been made with IMLOK*. It tells you about finishes and accessories, and even simplifies ordering for you! Always have the new IMLOK Manual by you for designing, constructing and ordering

always have the NEW IMLOK MANUAL by your side

send for your copy NOW

the imlok manual tells all!

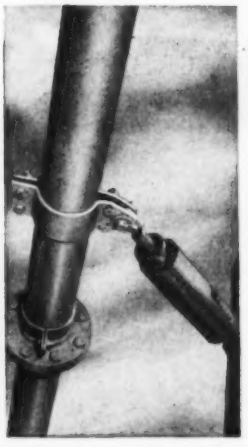
Alfred Imhof Ltd., Dept. N9, Ashley Works, Cowley Mill Road, Uxbridge, Middx. Uxbridge 37123

London Showrooms: 112-116 New Oxford St WC1 Museum 7878

IMHOFS AGENTS OVEARSEAS

Australia: Aladdin Industries (Pty) Ltd., Stanmore NSW
Belgium: Rogelec, Ghent
Canada: Measurement Engineering Ltd., Arnprior
Denmark: Tage Schouboe, Copenhagen N
Finland: Oy Scienta Ab, Helsinki
Germany: Sunvic Regler GMBH, Solingen Ohligs
Holland: J. Th. van Reijsen, Delft
Italy: Stuart Culley, Milan
New Zealand: Imarex Ltd., Auckland C3
Norway: Birger Christensen, Oslo
Portugal: Projectos e Construcoes Lda., Lisbon
Sweden: Elektronlund AB, Malmo C
Switzerland: Walter Blum, Zurich 2/39
U.S.A.: Bud Radio Inc., Cleveland 3, Ohio
Brit. Guiana: Davsons Caribbean Agencies Ltd., Georgetown

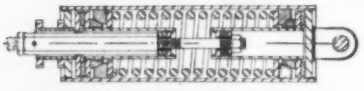
"Bracing" weather for pipework



Shocks and vibration give rise to high stresses in pipework, with possible subsequent damage to piping and associated equipment. Pipework on board ship subjected to vibration or in land installations exposed to high winds, is particularly prone to these hazards.

Vokes Genspring Non-Resonant Sway Braces supply an efficient form of control on all such pipework. These Sway Braces have many unique features including an incorporated energy-absorbing device, adjustability of initial restoring force, laminated cushioning material to reduce operational noise, and travel stops to prevent compression of springs to solid height. The eight different spring sizes cover loads from 39 lb. to 1,500 lb., with maximum restraining force varying from 100-2,250 lb. due to spring action.

Please write for descriptive booklet.



Vokes Genspring Non-Resonant Sway Braces

Sketches of suggested methods of application

Vokes Genspring SUSPENSION SYSTEMS

VOKES GENSPRING LTD · HENLEY PARK · GUILDFORD · SURREY

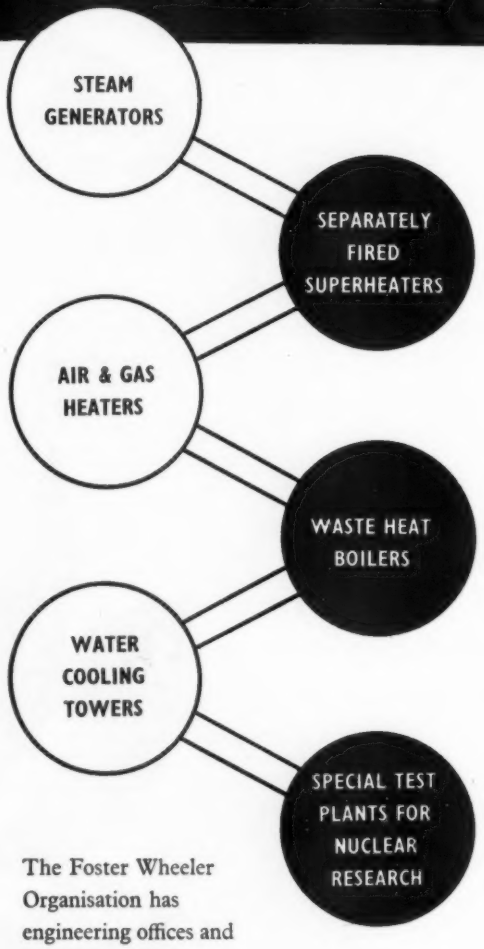
Telephone: Guildford 62861. Telegrams: Vokesacess, Guildford.
Telex: 8-535, Vokesacess. Guildford.

A member of the VOKES GROUP with world-wide representation

VG41

FOSTER WHEELER

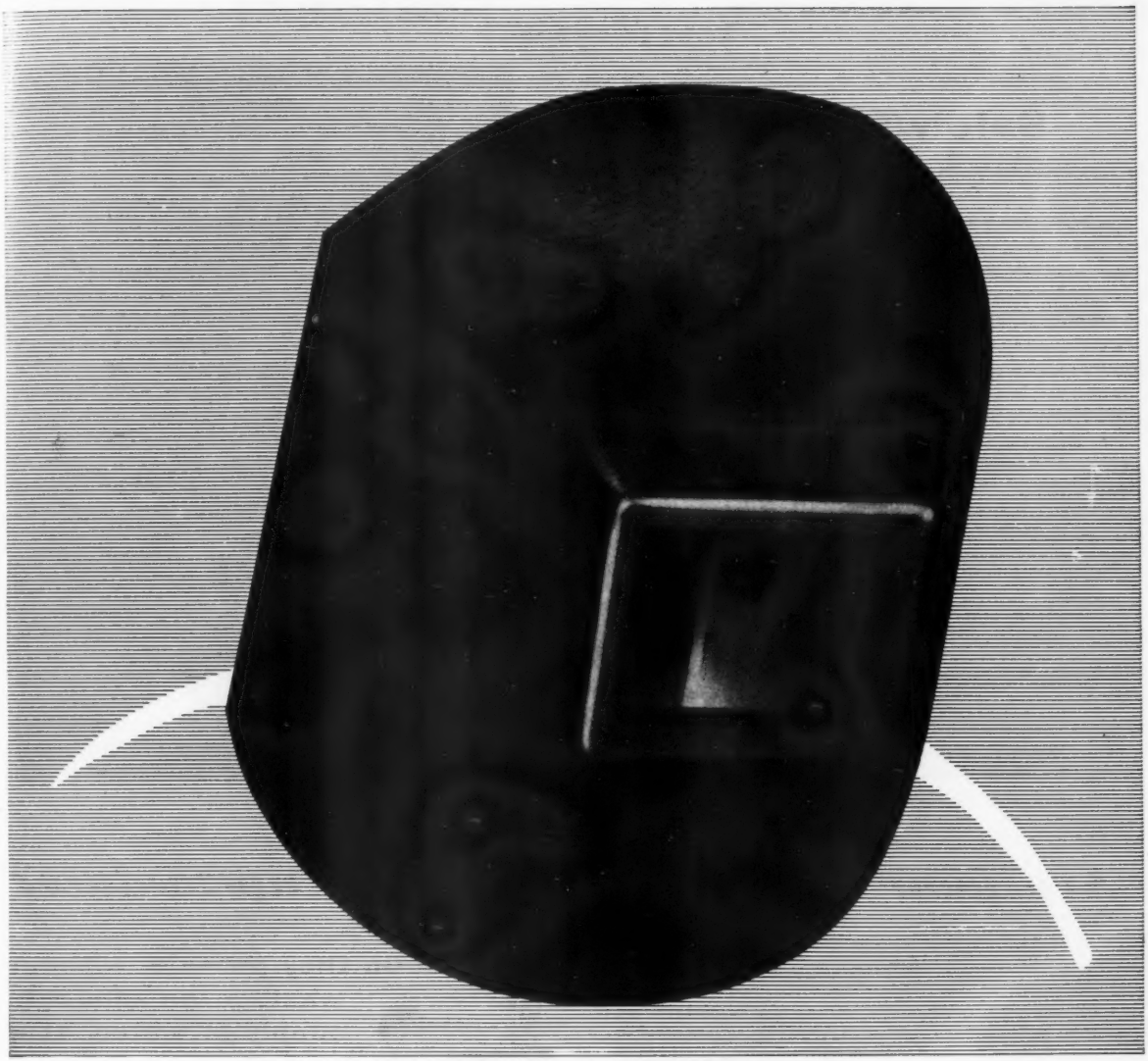
DESIGN AND BUILD



The Foster Wheeler Organisation has engineering offices and engineering plants in Great Britain, the United States of America, and Canada.

FOSTER WHEELER LIMITED

FOSTER WHEELER HOUSE, 3, IXWORTH PLACE, LONDON SW3. Telephone: KENsington 6363



The Right Helmet . . .

MUREX

Most welders prefer Murex helmets because they are right for protection, comfort and strength. They are made of high grade fibre or bonded laminated plastic and are completely shockproof, light in weight and comfortable to wear. Each helmet is fitted with an adjustable headband having an automatic locking device which enables the helmet to be held in the "up" position as long as desired. A patent Murex glass holder provides a dual purpose facility in the plastic type. The coloured filter glass can be raised or lowered in a fraction of a second so that the welder can sight his work right up to the moment of striking the arc.

Please write for full particulars.

MUREX WELDING PROCESSES LTD., WALTHAM CROSS, HERTS. ***Telephone: Waltham Cross 23636***

A11/343

Circle **No 127** on reply card for further details

The 'Vista' Mask

Safety in Comfort

At Siebe, Gorman & Co., comfort and efficiency go hand in hand: a fine example is the 'Vista' Mask.

The 'Vista' is a versatile mask that can be used with many types of equipment, from Compressed Air-line Apparatus to Gas Respirators. It is specially moulded for comfort and clear view—its plastic window is so shaped that vision remains undistorted at any angle. The air inlet is designed to prevent fogging, by deflecting inspired air over the inside of the window; and the mask itself can be tested for air-tightness before toxic atmosphere is entered. This is particularly important when it is used as a smoke mask—and the fitting we have designed for this purpose makes it impossible to wear the mask without both harness and lifeline, while the mask is still safe even if the bellows or blower are left unattended. Such thorough design is routine at Siebe, Gorman & Co.

The 'Vista' Mask is already in use with several Fire Brigades, and at the Atomic Energy Establishment, Harwell. It is approved by Ministry of Labour & National Service under Chemical Works Regulations, and the Ministry of Transport for use in ships. *Write to us for full details.*

Everything for Safety Everywhere

Air Compressors
Breathing Apparatus
Compression & Decompression Chambers
Diving Equipment
Dust Respirators
Gas & Fume Respirators
Protective Clothing
Resuscitation Equipment
Safety Helmets, Smoke Masks & Helmets

SIEBE GORMAN

SIEBE, GORMAN & CO. LTD.
Neptune Works, Davis Road,
Chessington, Surrey.
Telephone: Elmbridge 5900.
Manchester Office: 274 Deansgate.
Telephone: Deansgate 6000.

Are your Washroom Facilities up-to-date?

"SECURITY"—equipped washroom at Parkgate Iron and Steel Co. Ltd.

Do they provide, without wastage, an adequate supply of water, at a uniform, optimum temperature, and with complete dependability? In other words, are they equipped with

'SECURITY' THERMOSTATIC MIXING VALVES

featuring multiple, bi-metal element coils which ensure smooth positive action and high efficiency.

GUMMERS LTD

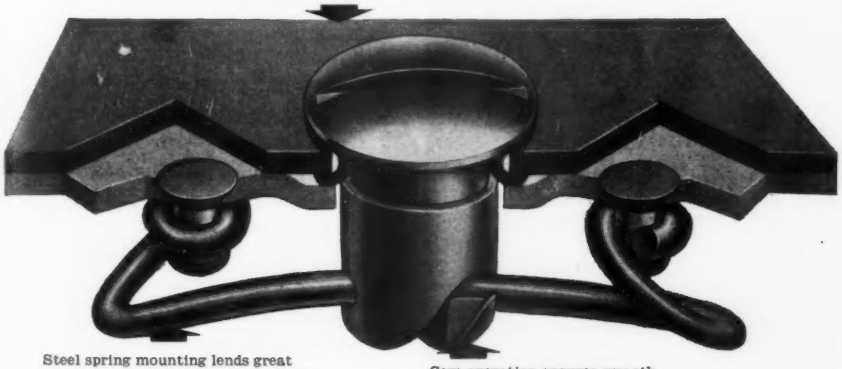
EFFINGHAM VALVE WORKS · ROTHERHAM · Tel: ROTHERHAM 4865-6-7 · Grams: "GUMMER" ROTHERHAM

Circle **No 128** on reply card for further details

Circle **No 129** on reply card for further details

the fastest fastener

The locked position. The Dzus Fastener is instantly unlocked by a quarter turn anti-clockwise.



Steel spring mounting lends great strength and guards against loosening, however intense the vibration.

Cam operation ensures smooth easy working yet unbreakable grip; fastener supplied to suit any thickness.

SURE..

SIMPLE..

SAFE..

- Dzus are fasteners with a world reputation for reliability. They can be fitted quite simply in any solid or laminated material regardless of thickness.
- Dzus are quick in action.
- Dzus are vibration-proof.
- Dzus are indispensable for hinged or removable parts in need of frequent inspection or attention.
- Dzus are the fastest fasteners with a variety of uses on Inspection Hatches and Panels, Engine Covers, Machinery Guards, Fascia Panels, Radiator Grilles and in the Electronic, Motor Vehicle, Air Conditioning, Heating and Shipbuilding Industries.

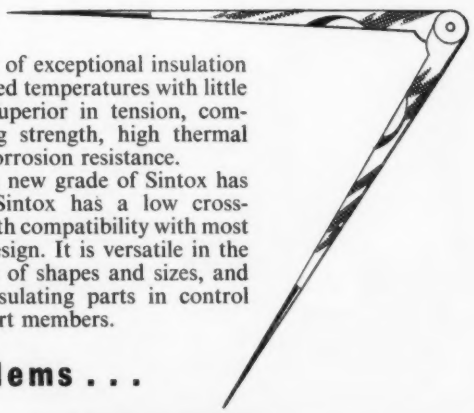
DZUS FASTENERS

Write for full details of applications in YOUR industry, to:

DZUS FASTENER EUROPE LTD. Farnham Factory Estate, Guildford Road, Farnham, Surrey.

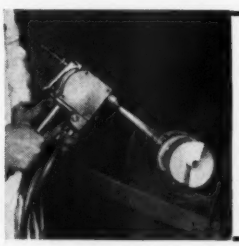
Sales Agents in U.K., Thomas P. Headland Ltd., Melon Road, Peckham, London, S.E.15.

material answer



Sintox, the alumina ceramic of exceptional insulation characteristics, stands elevated temperatures with little change in its properties. Superior in tension, compression and cross-breaking strength, high thermal conductivity and superior corrosion resistance.
For the Nuclear Engineer a new grade of Sintox has been developed. Nuclear Sintox has a low cross-section capture combined with compatibility with most materials used in reactor design. It is versatile in the production of a wide range of shapes and sizes, and particularly suitable for insulating parts in control gear, and mechanical support members.

to design problems . . .



Lodge have developed an alumina spraying process, giving thermal and erosion protection. Special leaflet on request.

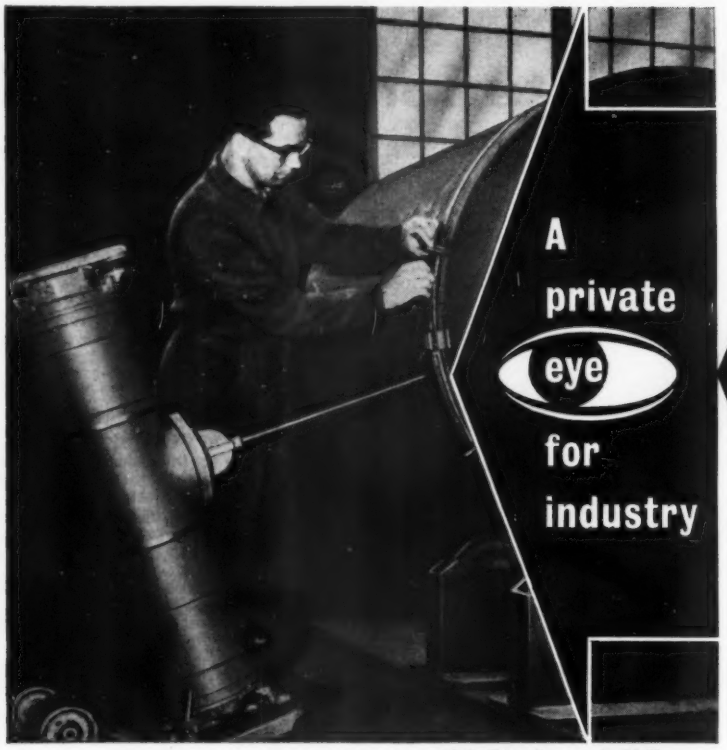
SINTOX

precision engineering ceramics

Sintox Technical Advisory Service. Freely available without obligation. Please write for booklet.

LODGE PLUGS LTD., RUGBY, ENGLAND Telephone: Rugby 2076

Circle **No 131** on reply card for further details



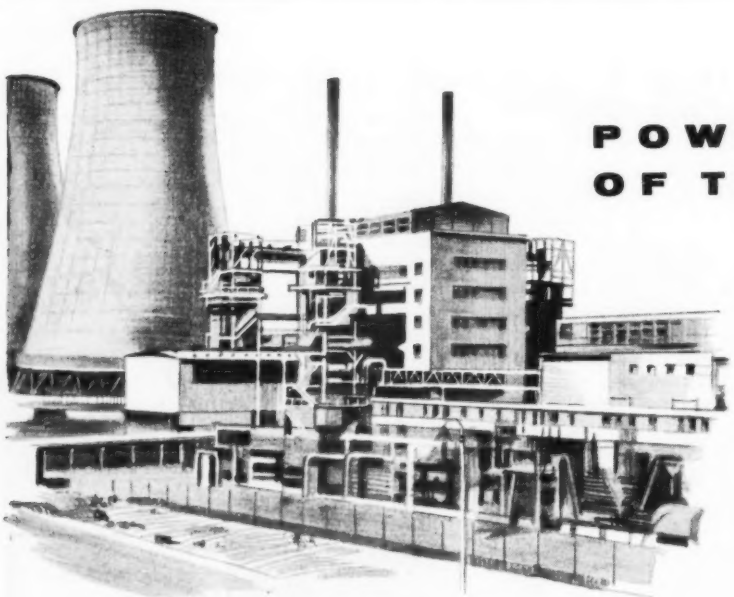
Ruggedly built, but still mobile, the Muller Macrotank H is specially developed for on-site radiographic examination in heavy industry, ship and bridge building, nuclear power and refinery construction — wherever complete and accurate weld examination is essential. The small focus (2.3 mm.) of the Macrotank H gives really sharp definition, with a penetration of up to 2¼" of steel with Pb screens in reasonable exposure time. It is low in cost, reliable in use, and backed by full service facilities which may be on contract if desired. We shall be glad to send you full details.
The Macrotank H is a product of C. H. F. Muller, Hamburg.

Sole Distributors in U.K.

RESEARCH AND CONTROL INSTRUMENTS LIMITED

Instrument House, 207, King's Cross Road, London, W.C.1. TERminus 2877

(RCL04166)



Calder Hall Atomic Power Station

POWER STATIONS OF THE NEW AGE

The economy, safety and long life of Staveley cast iron pipes need little more recommendation than their use under the trying technical conditions of Britain's nuclear power stations.

Whether carrying water, wastes or gas, Staveley pipes have withstood the test of years and benefited from every forward step in cast iron metallurgy and manufacturing practice.

STAVELEY **CAST IRON PIPES**

Telephone: Chesterfield 7251

THE STAVELEY IRON & CHEMICAL CO. LTD., NR. CHESTERFIELD

GORDON

IGEMA DISTANCE BOILER WATER LEVEL INDICATOR

BRADWELL	*72*	*INDICATORS*
BERKELEY	*64*	*„*
HINKLEY POINT	*24*	*„*
TOTAL	*160*	*FOR 3 POWER STATIONS*

Showing once again the complete confidence placed in the IGEMA INDICATOR for absolute ACCURACY and RELIABILITY in water level indication

JAMES GORDON & CO. LTD

DALSTON GARDENS, STANMORE, MIDDX

A MEMBER OF THE ELLIOTT-AUTOMATION GROUP

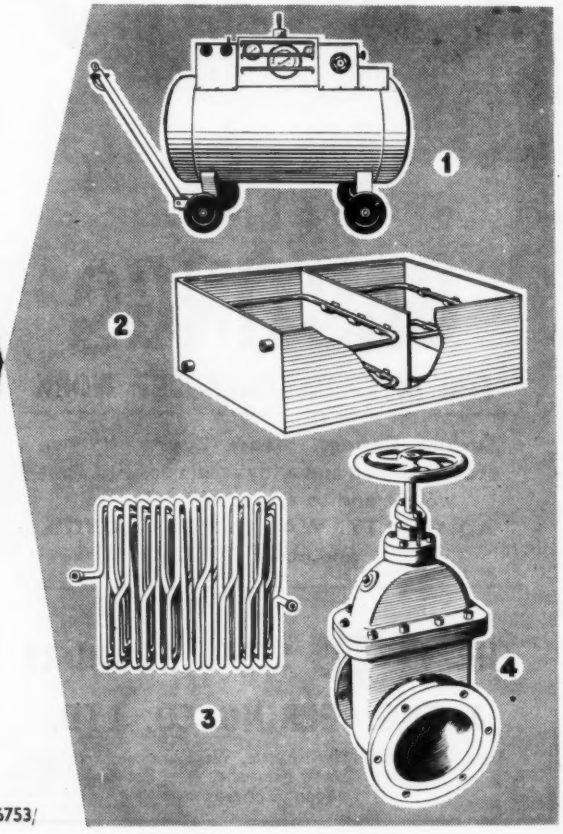
In this Nuclear Age of continual and exciting discoveries, high grade plant both in design and precision are important factors. We are therefore, proud to illustrate equipment specially produced for the exacting demands of the U.K.A.E. Authority.

Our activities include:

Fabrications in Stainless Steel, Aluminium, Copper, Brass, Steel and Alloys. Metallurgist's and Founders, Ferrous and Non-Ferrous Castings of all descriptions. Machine Work. All types of general machine work to close limits on modern plant. Testing and Inspections, Hydraulic Electrical and High Vacuum testing approved by U.K.A.E. Authorities and radiography

Progress

DEMANDS PRECISION



Liquid Nitrogen Transit Vessel supplied to United Kingdom, Australia and Danish Reactors 1

Stainless Steel Pickling Tank and Coils 2

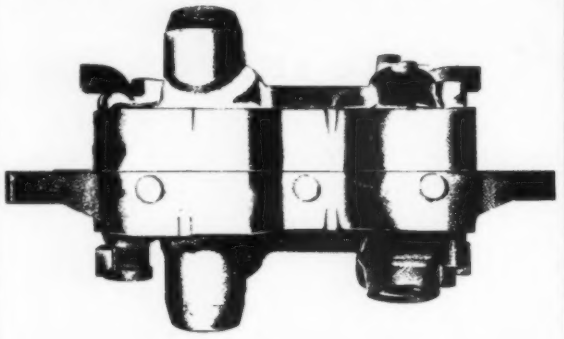
Stainless Steel Cooling Coil. 3

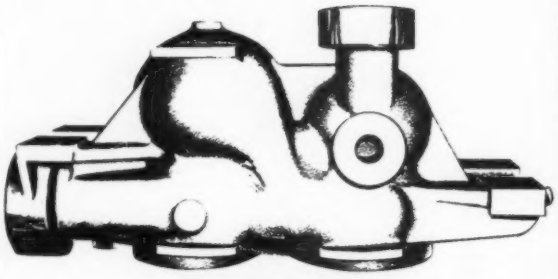
Aluminium Sluice Valve 4

THOS TR RYDER & CO. (MANCHESTER) LIMITED

GENERAL ENGINEERS & FOUNDERS, KNOTT MILL, MANCHESTER Tel. CEN 6753/

Circle **No 135** on reply card for further details





ATLAS

STEEL CASTINGS

FOR INTERNAL PRESSURE WORK

Turbine Casings, Steam Chests, Valves, etc., in carbon and alloy steels up to 15 tons weight and to any specification on ADMIRALTY, WAR OFFICE, LLOYD'S and other LISTS

THE ATLAS STEEL FOUNDRY & ENGINEERING CO. LTD.

Atlas Steel Works: Armadale, West Lothian, Scotland
Telegrams: "Atlas Armadale, West Lothian"
Telephone: 323 Armadale

Circle **No 136** on reply card for further details

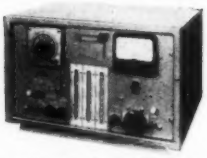
How to detect and measure α, β, γ

Choose one of these four combinations for a compact all-purpose laboratory:

1 ... or
1 + 2 ... or
1 + 3 ... or
1 + 2 + 3

1

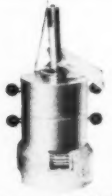
PROPORTIONAL COUNTING SYSTEM
(PC-3A)



Precision detection and counting of alpha and beta-gamma activity in prepared samples. No window absorption. Full 2 pi geometry. Sample analyzed directly inside detecting chamber. High voltage and scaling systems operate with US-1 and WSC-1 shown below. Accessories optional.

2

UNIVERSAL SHIELD
(US-1)
With beta-gamma G-M probe



Detects gamma and beta-gamma activity in prepared flat samples. Also accepts gamma scintillation detector, mylar window G-M flow detector, and strip chromatograph scanner. Operates with PC-3A.

3

WELL-TYPE SCINTILLATION COUNTER
(WSC-1)

Detects low-level gamma activity in test tube type samples. Also takes flat type samples. All-transistorized amplifier. Counter-balanced lid. Background lower than 140 cpm. Works with any scaler. Operates with PC-3A.

WRITE FOR CATALOGUE

NMC

Nuclear Measurements Corp.

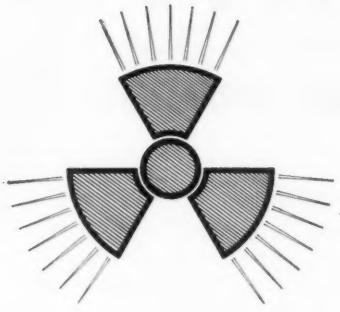
International Office:
13 E. 40th Street, New York 16, N. Y.

Circle **No 137** on reply card for further details

LEAD

ALL FORMS OF RADIATION PROTECTION

- CASTLES
- CONTAINERS
- COCKS
- BRICKS
- SHOT



- SHUTTERS
- DOORS
- POWDER
- TUBES
- SLABS

Licensed by the Commissariat à l'Energie Atomique, Paris

FONDERIE DE GENTILLY

56, rue Raymonde-Lefèvre GENTILLY (Seine) T. ALE 18,55

British & best

KING DICK
STILLSON PIPE
WRENCHES

King Dick Stillson Pipe Wrenches maintain the same high standard of quality expected with all our tools. The jaws are subject to a very rigid heat treatment control and are 100% hardness-tested to ensure reliability. All the individual parts are interchangeable.
Available in 8″ 10″ 14″ 18″ 24″ 36″ and 48″ sizes. Write for illustrated leaflet.

BUY KING DICK BRITISH

BINGDON
KING DICK

Abingdon Works,
Kings Road,
Tyseley, Birmingham 11
England.

Circle **No 138** on reply card for further details

Circle **No 139** on reply card for further details

THE ELEMENTS

of efficient angular drives

- A.R.B. approved
- 92-98% efficient—N.P.L. certified
- Used by leading engineering companies in every industry
- For shaft diameters ¼" to 1⅝"
- Dirt-excluding covers can be supplied

A.M. Gauge-Test House Authority No. 89755/31

UNIVERSAL BALL JOINTS

Sturdy, reliable, compact couplings of simple design, manufactured from high-grade materials, and available with single or double joints in nine standard sizes.

MOLLART ENGINEERING COMPANY LIMITED

KINGSTON-BY-PASS · SURBITON · SURREY

Telephone : Elmbridge 0033-7 *Telegrams : Precision Surbiton*

Circle **No 140** on reply card for further details

Portable . . .

TYPE MC—1 (MK.III)

CONDUCTIVITY MEASURING BRIDGE

The type MC-1 conductivity bridge is an invaluable aid to the water engineer in the laboratory or in the field, for the determination of water purity, where it may be depended upon for precise, accurate measurement and trouble free service.

The instrument is supplied complete with an ELECTRONIC SWITCHGEAR patented, non-glass conductivity measuring cell and all accessories, in a convenient hardwood carrying case. The development of low power consumption transistorised circuits, which operate from a small long life dry battery, has resulted in the production of a particularly compact and lightweight precision instrument.

Descriptive leaflet MC-1 available on request.

ELECTRONIC SWITCHGEAR

(LONDON) LTD.

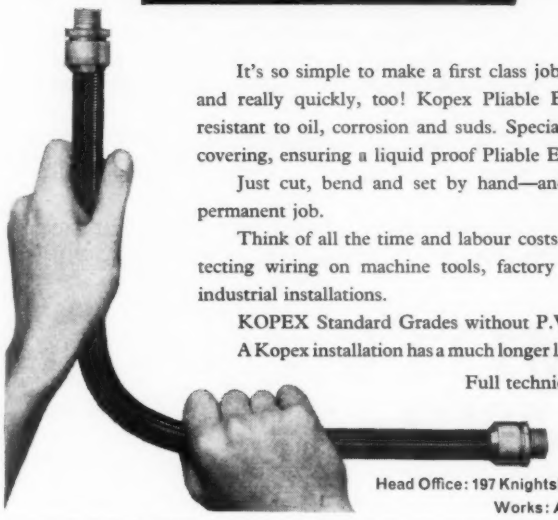
LETCHWORTH · HERTS · TEL: 1853

ELECTROLYTIC CONDUCTIVITY MEASURING SETS, RECORDERS, CONTROLLERS AND CELLS · CONTROLS FOR LIQUID AND SOLID LEVELS · TIMING · PHOTO-ELECTRIC PACKAGING REGISTRATION · ETC.

47 VICTORIA STREET WESTMINSTER, S.W.1 ABBEY 2771/5

CUT, BEND, SET BY HAND

that's all you do with **KOPEX** P.V.C. COVERED PLIABLE ELECTRICAL CONDUIT



It's so simple to make a first class job of an awkward, intricate wiring layout—and really quickly, too! Kopex Pliable Electrical Conduit is P.V.C. covered and resistant to oil, corrosion and suds. Special duralumin couplings fit over the P.V.C. covering, ensuring a liquid proof Pliable Electrical Conduit connection.

Just cut, bend and set by hand—and what do you get? A neat, semi-rigid, permanent job.

Think of all the time and labour costs you save! It is especially suitable for protecting wiring on machine tools, factory equipment, chemical plants and general industrial installations.

KOPEX Standard Grades without P.V.C. covering are also available.

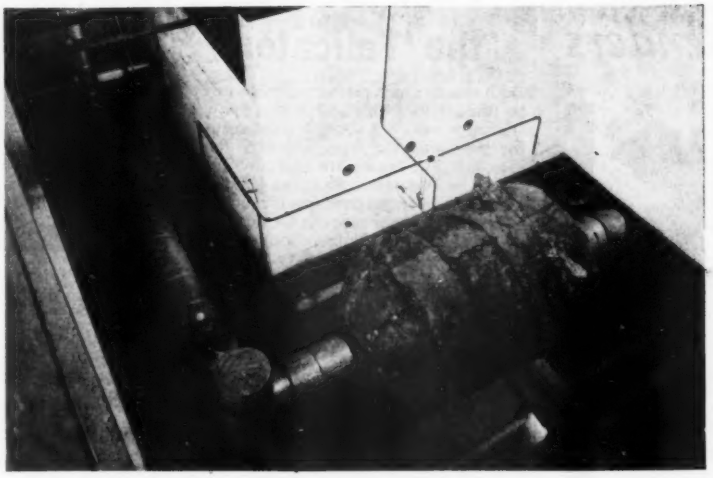
A Kopex installation has a much longer life than any other type of flexible connection.

Full technical information and prices sent on request.

UNI-TUBES LTD

Head Office: 197 Knightsbridge, London S.W.7. Tel: KNightsbridge 7811/5
Works: Alpha Street, Slough, Bucks. Tel: SLough 25476/8

Jansen Brassfounding and finishing for the nuclear industry



- Valves
- Shut-offs
- Non-return valves

Flow regulation and shut-off at the highest temperatures and pressures for all applications.

Available with fully automatic control.

Th. Jansen S.A. — Rethel (Ardennes)

Tel: 390-391 RETHEL, Cable address: JANSEN RETHEL

Telex: JANSEN — RETHEL No NANCY 83070

Circle **No 143** on reply card for further details

Seventy five years young

For three-quarters of a century Gummers Limited of Rotherham have been in the forefront of the manufacture of steam valves which they are now supplying to meet Britain's needs in the latest field of technical advancement—Nuclear Power.

A typical example is the Angle Gas Valve supplied for operation in pipelines carrying gaseous Freon 2, at temperatures between 0° and 50° C and at 60 lbs. pressure (although they are capable of carrying higher pressures up to 400 lbs. if necessary).

Gummers high ranking standard construction employs only the finest materials and practice including top quality Meehanite castings for bodies and covers, and cadmium plating of the mild steel parts to ensure long life and freedom from corrosion.

The advanced design incorporates many special features such as P.T.F.E. V-Ring Seals, which eliminate stem binding yet give a positive seal at all pressures.

In the future when more highly developed valves are called for to meet the needs of further scientific and technological advancement, Gummers will make them.

GUMMERS LIMITED

EFFINGHAM VALVE WORKS · ROTHERHAM

Tel: Rotherham 4865-6-7 Grams: Gummer, Rotherham *London Office: 38, Victoria Street, S.W.1. Tel: London ABBey 6473*

Circle **No 144** on reply card for further details

Tubela *Hydraulic Benders*

Bending all classes of steam and gas tube from ½ to 2 inch bore is child's play with the Tubela H3PR.

The double-acting hydraulic ram which releases the tube from the former without using wedges or hammer.

Extension wingheads and formers can be supplied to increase capacity to 2½ and 3 inches.

Industrial 4H

Hand operated hydraulic model for bending cold and unloaded 2 to 4 inch n.b. pipe.

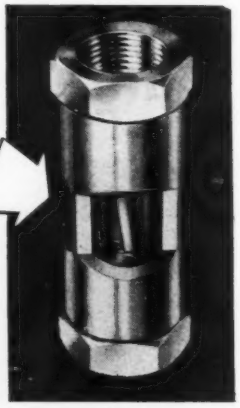
Write now for illustrated brochures of the competitively priced range of Tubela benders. Hand, ratchet, hydraulic and motorised models with capacities from ½ to 12 inches.

Tubela *The Bending People*

TUBELA ENGINEERING CO. LTD.,
Fowler Road, Hainault, Essex Hainault 4426/8 TA3371

Circle **No 145** on reply card for further details

See the flow with the 'Telicator'



Both low and high pressure systems can be fitted with a Telicator Visual Flow Indicator, which is a simple instrument for indicating the flow, whatever the viscosity. The rotors are specially designed by Dukes and Briggs to give the clearest indications over specific ranges of flow rate. Water supplies for cooling purposes and forced lubrication systems are two typical applications. A new model is under development for use with opaque fluids, and special designs can be made to meet specific requirements.

Note these features

- *Simple design ensures complete reliability.*
- *Extreme sensitivity at all pressures.*
- *Units readily adaptable to existing installations.*
- *May be mounted in any plane.*
- *Comparative flow gauged by speed of revolving rotor.*

Bailey's REGD.

SIR W. H. BAILEY & COMPANY · LIMITED
PATRICROFT · MANCHESTER · ENGLAND
Phone: Eccles 3487-8-9 Grams: Beacon, Telex, Eccles
LONDON OFFICE: SELINAS LANE, DAGENHAM ESSEX. PHONE: DOMINION 2277/8/9
TGA TRI

Circle **No 146** on reply card for further details

EARTHBOUND OR AIRBORNE

Matching man's swiftest soaring thought,

showing the best way to pack a punch—

The products and services of the M.B.M. Group meet the urgent needs of the day.

Operations cover: electro-mechanical components and equipment, electronic equipment and complete systems.

Products include: aircraft lighting systems, miniature micro-switches, pressure switches, butting connectors, terminations, plugs and sockets.

Services embrace: design and development, manufacture, environmental testing, packaging.

Immediate action available from

TECHNICAL SALES OFFICE — M. B. METALS LIMITED
VALE WORKS · PORTSLADE
SUSSEX · ENGLAND

Telephones:—Technical Sales Office: Hove 46275
Works: Hove 48623

Circle **No 147** on reply card for further details

TIME CLOCK CARDS

TO FIT EVERY TYPE OF MACHINE

EXACTLY TO YOUR REQUIREMENTS

Our Time Cards are manufactured with extreme care and we guarantee them to be trouble free.

7 DAYS' DELIVERY	TOP QUALITY	LOW PRICE

You cannot do better than by dealing direct with the largest manufacturers in the country.

We can quote for any type of Card by return:
Send us your samples today.

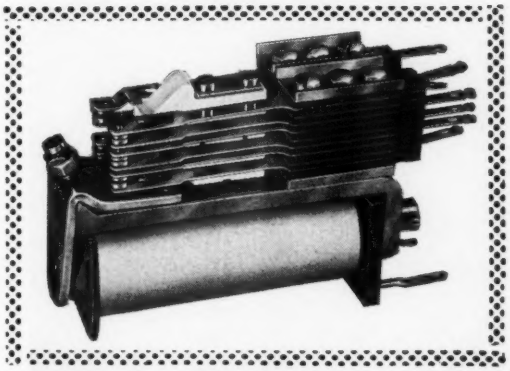
HARLOW

HARLOW PRINTING WORKS (NORTHERN) LTD.
104-110 FREDERICK STREET
SOUTH SHIELDS
Telephone: ST. HILDA 4286 (3 lines)

Circle **No 148** on reply card for further details

RELAYS

TO SPECIFICATION



POST OFFICE TYPE

3,000 and 600 RELAYS

Specialists in tropical and Services jungle finish.
Guaranteed to full A.I.D. and I.E.M.E. standards.
Prompt Deliveries Prototypes within 24 hours.
Post Office approved. All relays guaranteed made in our own works.
P.T.F.E. insulation now available.

SIMMONDS

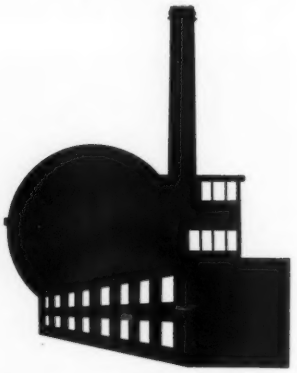
Manufacturers to H.M. Government Departments and leading Contractors
L. E. SIMMONDS LIMITED, 5 BYRON ROAD, HARROW, MIDDX.
TELEPHONE: HARROW 7797/9 TELEGRAMS: SIMRELAY HARROW

Circle **No 149** on reply card for further details

SPECIAL STEELS

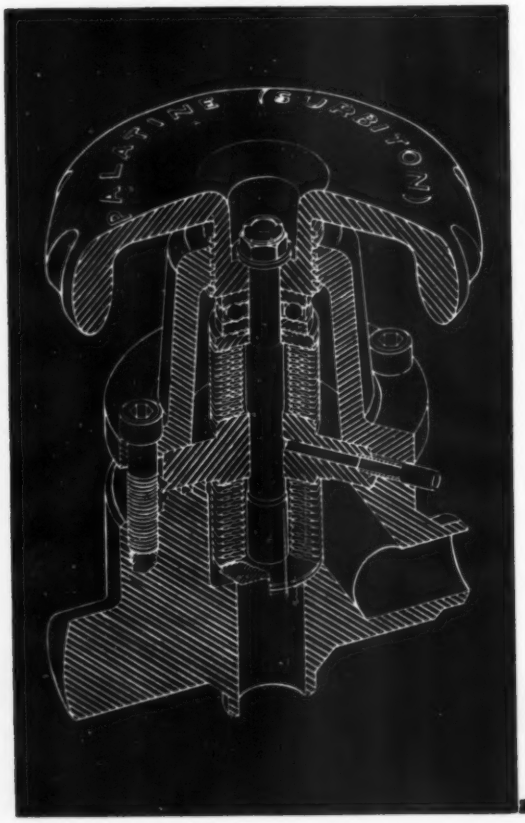
FOR THIS MODERN AGE

- STAINLESS STEELS
- HEAT RESISTING STEELS
- VALVE STEELS
- HIGH SPEED STEELS
- TOOL & DIE STEELS



ARE OUR BUSINESS

C. G. CARLISLE & CO. LTD. IONA WORKS, PENISTONE ROAD, SHEFFIELD. *Telephone : 348791*



POSITIVELY SEALED GLANDLESS VALVES

Suitable for a wide variety of liquids and gases. Toxic—Radioactive—Corrosive or Explosive.

- ROBUST & COMPACT
- POSITIVE METALLIC BELLOWS SEALING
- EASY CONTROL
- MINIMUM OPERATING EFFORT
- FORGED LEAKPROOF BODIES
- HARD FACED POPPET OR DISC INSERTS

Palatine design and supply a wide variety of Valves to U.K.A.E.A. at Capenhurst, Aldermaston, Harwell, etc. and to the Chemical and Petroleum Industries.

REMOTE CONTROL VALVES OPERATED BY AIR DIAPHRAGM OR PNEUMATIC MOTORS—ELECTRIC ACTUATORS—VERY COMPACT HIGH TEMPERATURE —VACUUM—LIQUID VALVES. PORTING AND STUBS TO CUSTOMER'S REQUIREMENTS.

PALATINE (SURBITON) LIMITED

64/76 BRIGHTON ROAD · SURBITON · SURREY

TELEPHONE ELMBRIDGE 7261-3

Circle **No 151** on reply card for further details

interested in Pure metals?

chromium — four purity grades available—all over 99.0% pure

niobium — available as beads, roundels, electrodes and ingots

silicon — seven purity grades available—all over 98.0%

tantalum — available as roundels, dendrites, electrodes and many wrought shapes

vanadium — powder at 99.5% purity grade, mill products at higher purity

MANY CHEMICAL COMPOUNDS ARE AVAILABLE OF THESE AND OTHER METALS

Full information on rarer metals and their compounds is available on request

UNION CARBIDE TRADE MARK

Alloys Division

UNION CARBIDE LTD

R4. 8 GRAFTON STREET, LONDON, W.1

Circle **No 152** on reply card for further details

TEST SIEVE SHAKER *for* accurate particle size analysis

Accurate and consistent results are the features required of a test sieve shaker for the sieve analysis of the particle size range of material. Simply vibrating or shaking test sieves by hand is not good enough for the standard of accuracy required these days. Vibration alone tends to aggregate rather than to segregate particles and shaking test sieves by hand is not only tedious but inevitably produces inaccurate results.

The **Inclyno Test Sieve Shaker** incorporates a double movement that jolts and spreads the test material ensuring perfect segregation of the various particle sizes and presenting the maximum number of apertures for undersize particles to fall through each sieve. Three models available for all sizes of standard test sieves and supplied complete with motor and inbuilt automatic time switch covering test periods up to 60 minutes.

INCLYNO

Write or telephone Crawley 25166 for List IN 3209

THE PASCALL ENGINEERING CO LTD
GATWICK ROAD · CRAWLEY · SUSSEX

Circle **No 153** on reply card for further details

When Cooling's a Problem . . .

Call in **PREMIER** for expert advice

Undoubtedly the answer to all air and hydrogen cooling problems is PREMIER. PREMIER closed circuit coolers are among the most highly efficient and economical in the world—installed in such important power stations as Meaford, Poole, Uskmouth, Hams Hall "C", Darlington, Bold "B", Stockport and Johannesburg; and hydrogen coolers and heat exchangers in hand for Hunterston Atomic Power Station and many other important overseas works and power stations, large and small. PREMIER design and erect the plants, guarantee the performance and give a 100 per cent. after-sales service. Certainly, the scientifically engineered construction and high efficiency and economy of PREMIER closed circuit air coolers is the reason why they are acclaimed by engineers everywhere.

If you have an air or hydrogen cooling problem, write to us—our advice is yours for the asking.

WE *do the designing ourselves*
WE *erect the plants ourselves*
WE *manufacture our own plants*
WE *guarantee the performance*

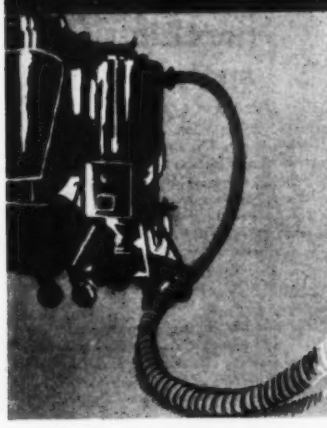
PREMIER COOLING TOWERS
THE PREMIER COOLER & ENGINEERING CO. LTD.
SHALFORD · NR. GUILDFORD · SURREY

Circle **No 154** on reply card for further details

VACU-BLAST

for shot blasting tubes of any size from $\frac{1}{8}$ inch bore upwards

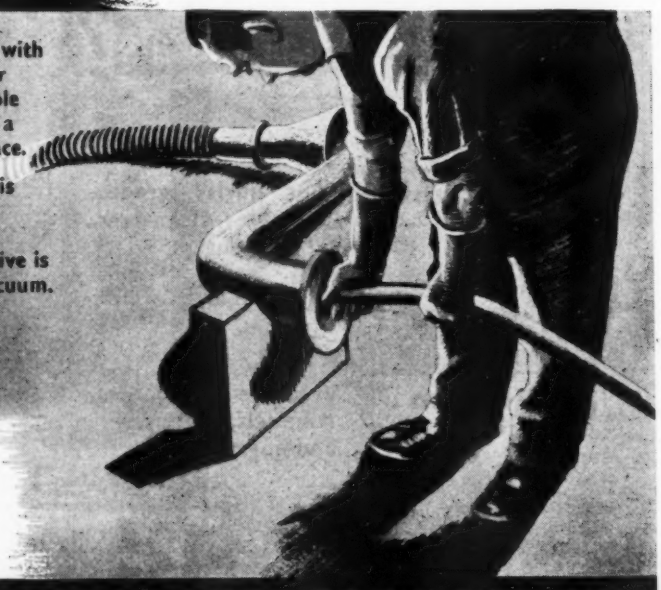
the only effective way to remove scale, fused sand and corrosion products from the internal surface of tubes of practically any shape or size.



used in conjunction with the Vacu-Blast Major machine, these simple attachments ensure a perfectly clean surface.

All dust and debris is confined within the Vacu-Blast closed system. Spent abrasive is recovered under vacuum.

Can be used in the open shop or in the field.

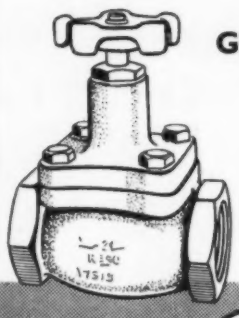


We invite you to submit sample tubes so that we may demonstrate the method and advise on plant accessories to suit your requirement

VACU-BLAST LIMITED, BATH ROAD, SLOUGH, BUCKS, ENGLAND.

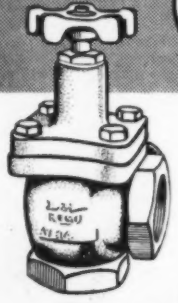
TELEPHONE : SLOUGH 24507/9

Circle **No 155** on reply card for further details



GLOBE and ANGLE VALVES with COUNTLESS APPLICATIONS

REGO



TG SERIES

$\frac{3}{4}$"–4" • Screwed or flanged connections • Ductile Iron bodies • Stainless Steel spindles • Teflon seat discs and "V" ring pressure seal.

Further details from:

LP-GAS EQUIPMENT LIMITED

PERCY ROAD · GREET · BIRMINGHAM 11

A member of the WBG *Group*

Circle **No 156** on reply card for further details

ENDECOTTS

TEST SIEVES

For Accuracy!

POCKET INTERCHANGER SIEVES

'ENDROCK' TEST SIEVE SHAKER

TEST SIEVES

B.S. 410: 43 U.S. Standards and Tyler Equivalents

We operate a Recovering Service

Consistent mechanical action — saves valuable time of skilled personnel

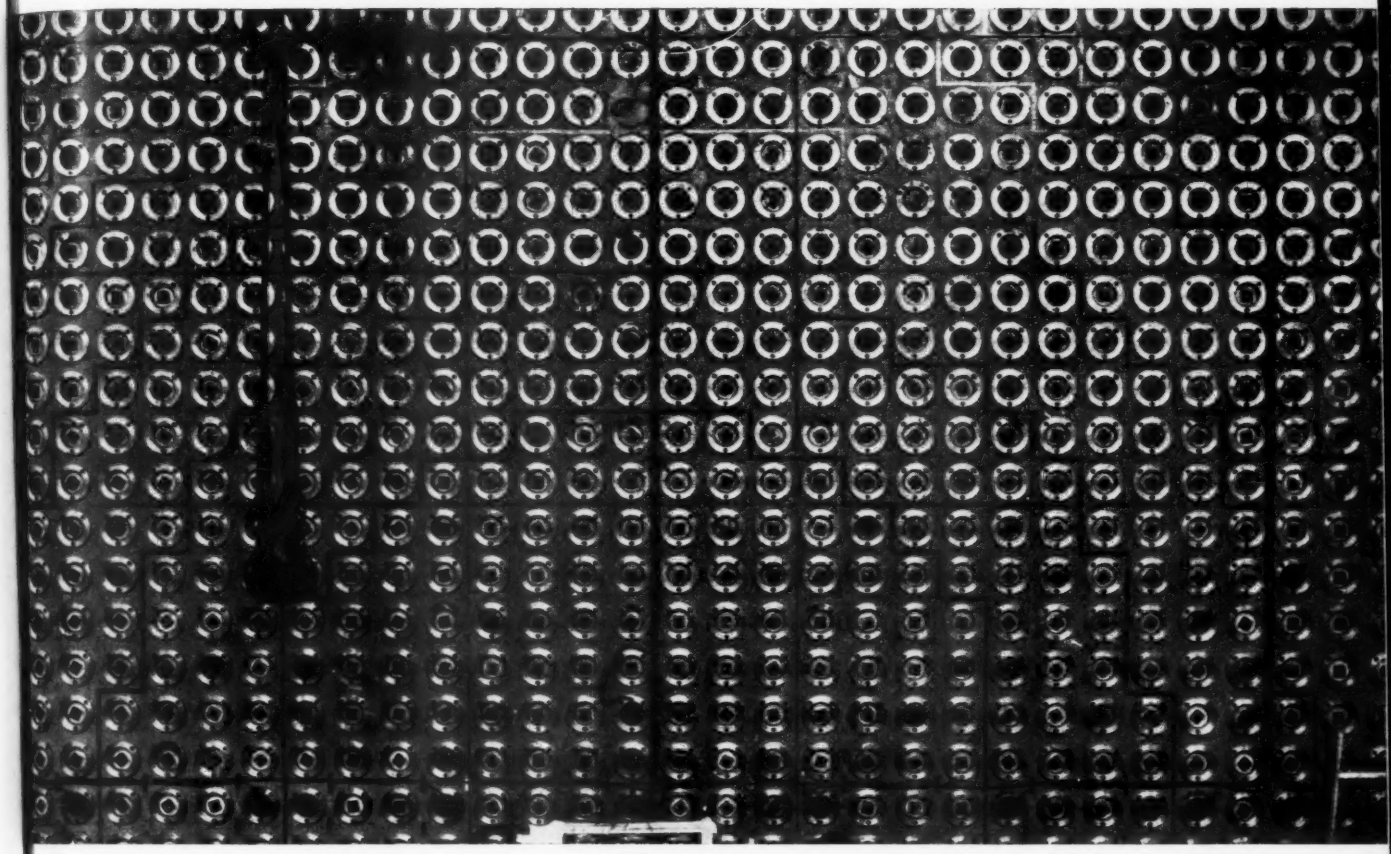
ENDECOTTS (FILTERS) LTD.

Dept. A. Lombard Road, London, S.W.19.

Phone: **LIBerty 8121/2/3**

Grams: **Endfilt, London**

A BREAKDOWN HERE COULD COST A FORTUNE



What is the most important piece of machinery in your factory ?

What would be the cost per day to your business if it were to break down ?

It is now possible to cover the loss of profits resulting from such a breakdown as well as the cost of repairing the machine itself.

Policies can be issued to meet the particular requirements of any business.

In this way you can be indemnified against the serious interruptions to your business which can be caused by machinery breakdown.

Should you feel in need of the protection of this new form of insurance we can send an engineer to advise you and inspect your plant.

Write to **D. H. EVERS,** *Industrial insurance consultant*
ONE ARUNDEL COURT JUBILEE PLACE LONDON S.W.3

CLASSIFIED ADVERTISEMENTS

DISPLAY ANNOUNCEMENT RATES:— 1 insertion 50/- per single col. inch
6 insertions 47/6 per single col. inch
12 insertions 45/- per single col. inch

LINEAGE ANNOUNCEMENT RATES:— 5/- per line. 5% discount for 6 insertions, 10% discount 12 insertions

BOX Nos.:— 1/- extra will be charged

COPY DATE:— Advertisements for October issue to be received not later than September 14th

SITUATIONS VACANT

SALES ENGINEERS REQUIRED

by a leading company manufacturing high precision Components, Mechanisms and Machines, with Technical Design, Research, and Development Departments.

Candidates, preferably 30–35, should possess Honours Degree in Mechanics and/or Electronics with a proved ability to negotiate at all levels and be conversant with the development of new equipment and techniques.

Car. Non-contributory Life Insurance and Superannuation.

Commencing Salary £1750 in a progressive and interesting career.

Full experience to Director, Box No. NP207.

PLANNING AND PROGRESS ENGINEER

required by the United Kingdom Atomic Energy Authority, Production Group, Springfields Works, Salwick, Preston, Lancashire, to be responsible to the Senior Planning Engineer for planning and progressing of engineering projects carried out by the Works Engineering Department; co-ordination of work of sections of the Engineering Department, including Design; and operation of a comprehensive planned maintenance scheme.

A recognised engineering apprenticeship, corporate membership of a senior engineering institution, or equivalent, and extensive experience in planning and progress as applied to a large Works Engineering Department, are essential. Experience in initiation and operation of planned preventative maintenance schemes is desirable.

Salary: £1370 to £1825 per annum.

Staff Housing Scheme. Contributory Superannuation.

Send postcard for application form, quoting reference SF.50/J.28, to Works Secretary at above address.

Closing date: 26th August, 1960.

POWER AND PROPULSION

Engineer required for design and development work on heat exchangers, steam generators, pressure vessels and other components associated with advanced types of nuclear reactors and with other advanced systems in the power and propulsion field.

Applicants should have academic qualifications of engineering degree standard and should preferably have some previous experience in design and/or development work.

Commencing salary within the range £950—£1,250 p.a. according to age and experience.

Write:—**Staff Manager,**
Foster Wheeler Limited,
3 Ixworth Place,
London, S.W.3.

NUCLEAR FUEL ELEMENT DEVELOPMENT

An engineer, physicist or metallurgist is required by the Research and Development Branch at Springfields Laboratories, Salwick, near Preston, Lancashire, to originate and progress nuclear fuel element development work undertaken on Contract to the Authority by outside bodies and to co-ordinate joint development programmes undertaken by the Authority with such bodies. He will represent the Branch at technical development meetings and act as advisor on the results of the development work and on the initiation of further researches.

The fields of work covered range from metallurgical considerations relevant to the fuels and canning materials to physical, metallurgical and mechanical considerations relating to the reactor performance of elements. A broadly based scientific or technological background would therefore be advantageous. At least a second class honours degree is required together with at least 3 years' post-graduate research experience.

Starting salary will be assessed on the scale £1,740—£2,460 according to qualifications and experience.

Staff housing scheme. Contributory Superannuation.

Send postcard for application form quoting reference 346/J.28 to:—
SENIOR RECRUITMENT OFFICER,
UNITED KINGDOM
ATOMIC ENERGY AUTHORITY,
DEVELOPMENT AND ENGINEERING
GROUP HEADQUARTERS,
RISLEY, WARRINGTON, LANCASHIRE

Closing date: 12th September, 1960

COURSES

BOROUGH POLYTECHNIC

Borough Road, London, S.E.1

Department of Electrical Engineering and Physics—Session 1960/61

COURSES IN NUCLEAR TECHNOLOGY

Lecture Courses

Courses of evening lectures by specialist lecturers from U.K.A.E.A., Industry and Colleges, are held weekly on the following subjects:

NUCLEAR PHYSICS FOR NUCLEAR POWER—11 Lectures commencing 6th October, 1960, with supporting laboratory work in afternoons.
NUCLEAR POWER TECHNOLOGY—12 Lectures commencing 12th January, 1961.
NUCLEONIC CIRCUITRY—10 Lectures commencing 5th October, 1960.
NUCLEAR PARTICLE TECHNIQUES—15 Lectures commencing 11th January, 1961.
REACTOR INSTRUMENTATION AND CONTROL—6 Lectures commencing 13th April, 1961.

Laboratory Courses

NUCLEONIC TECHNIQUES AND MEASUREMENTS—Part-time Course held on Friday afternoons and evenings commencing 7th October, 1960, or on Tuesday mornings and afternoons, commencing 4th October, 1960.
Full-time courses of two months duration on the same subject commence on 7th October, 1960 and 10th April, 1961.

Further details from:—
The Secretary, Borough Polytechnic,
Borough Road, London, S.E.1

MISCELLANEOUS

PLUGS AND SOCKETS

More than 1,000,000 in stock, covering over 50 different ranges, British and American

•

Stock list on application to:

SASCO

Nutfield, Redhill, Surrey

Telephone: Redhill 5050

TECHNICAL TRANSLATIONS by a team of graduate experts, covering many technical fields and languages. P. Suchodolski, F.I.L.(Eng.), 70 Greenfield Gardens, London, N.W.2. Telephone: MEAdway 2239.

Telephone your classified advertisement to MUSEUM 8252

AT YOUR SERVICE

when you need an expert

FOR ALL METAL FINISHES
Electro Plating in Rhodium, Gold, Silver, Cadmium, Chromium, Nickel, Copper, Tin, Zinc, Lead, etc, Enamelling, Lacquering, Shot-Blasting, etc.
A.I.D., A.R.B., D.I.A.R.M. Approved.
HARRIS PLATING WORKS LTD.
18 New Wharf Road, London, N.1. TERminus 7263 (5 lines)

DUPLOYEN
FOR ALL LANGUAGES . . .
Technical, legal and commercial translations by experts.
Intensive tuition for busy people
16-18 Edmund Street, Birmingham, 3
Tel.: Birmingham CENtral 5431

HEAVY HAULAGE
Machinery Dismantling and Erection
STORAGE — OPEN & COVERED
CRANE HIRE
ANNIS & CO. LTD.,
Pump Lane, Hayes, Middlesex.
Telephone: HAYes 0456

ASH & LACY LTD.
PERFORATORS OF
Steel, Aluminium, Copper, Brass, Zinc, Tinplate, Stainless Steel, and many other materials in all gauges for all industrial purposes.
Meriden Street, Birmingham, 5. Birmingham: MIDland 6371

Specialists in the analytical and mechanical testing of all metallic materials. Approved by D.G.I., Air Registration Board, Ministry of Transport, and Lloyds.
ACLOQUE (Metallurgists) Ltd.,
ABBey 1481
Test House, Garth Road, Lower Morden, Surrey. DERwent 6252

Higher Tensile Steel Chain Slings and special Lifting Appliances of every description D.G.I. approved
T. SMITH & CLARKE LTD.,
Chain Manufacturers,
Port Tennant, Swansea
Telephone No. 53106 (4 lines)

ALUMINIUM DESIGN
and fabrication service available for all types welded and other light alloy structures and components
ALPHAMIN LTD.
4 Dunston Street, Kingsland Road, London, E.8. Tel.: CLIssold 4161

PERSPECTIVE AND SECTION DRAWING
In colour, line and monochrome
Complete technical booklets undertaken
HILTON AND KAY LIMITED
4 Water Street, Manchester 3
'phone Blackfriars 0402. Est. 30 years
High quality Low costs

PRACTITIONERS IN THE ART OF SCALE MODELS AND PATTERNS
All types of scale models.
Quality — Delivery — Service
Contractors to the U.K.A.E.A.
●
MASTERMODELS LTD.
Greenhill Crescent, Harrow, Middx.
Telephone: HARrow 2428

C. W. GARRETT & SON LTD.,
for
ALL DRAWING OFFICE SERVICES. PROCESSES, MATERIALS AND EQUIPMENT
●
WINDMILL ROAD, BRENTFORD MIDDLESEX
Telephone : ISLeworth 4433 (4 lines)

NON-DESTRUCTIVE TESTING LABORATORIES
Vacuum, X-Ray, Gamma-Ray and other forms of Non-Destructive Testing.
●
INDUSTRIAL RADIOGRAPHY (N.D.T.) LTD.,
Managing Director: Paul Fox
360 Cricket Inn Road, Sheffield, 2
Telephone:—Sheffield 26630

R. & J. PARK LTD
Dominion Works, Chiswick England
●
Export packers, shippers and forwarding agents. Specialists in packing heavy machinery

X-RADIOGRAPHY
of welds and castings offered up to 1½" thickness, also high vacuum test facilities.
IMMEDIATE SERVICE
THOS. RYDER & CO. MANCHESTER LTD.,
COMMERCIAL STREET WORKS, KNOTT MILL, MANCHESTER 15
Central 6753

L. & P. PLASTICS LTD.
TRADE INJECTION MOULDERS
1-16 oz. capacity, toolmaking and moulding in Nylon, Acetate, Polythene, Polystyrene, Diakon, P.V.C., Polycarbonate, etc.
Individual prompt service and keen prices.
Hawthorn Grove, Penge, London, S.E.20 SYDenham 2331 (4 lines)

GILSTON ENGINEERING CO.
Specialists in all applications of STAINLESS STEEL
Fabrications Press Tools
Precision and Production Engineers
Lea Road, Waltham Abbey, Essex
Telephone: Waltham Cross 23871

PRECISION ENGRAVING of Instrument Panels, Dials, Scales, Nameplates, Labels, etc. Plastic Components, "Perspex", fabrications. Stockists of "Perspex", Acetate, Traffolyte, etc. Speedy deliveries on long or short runs. A.R.B. and A.I.D. approved.
LEICESTER ENGRAVERS (PLASTICS), LTD.
60 Edwyn Street, Leicester. Phone 58375

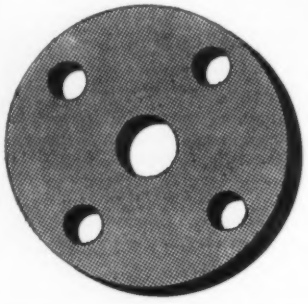
Established 1825

"ATMOS" VALVES

for Combined Pressure & Vacuum Relief and FLAME ARRESTERS

have been safely venting Storage Installations throughout the World for nearly half a century.
Approved by the Air Ministry, Ministry of Transport, Lloyd's Register of Shipping, etc.

Sole Manufacturers: **BLUNDELL & CROMPTON LIMITED**
WEST INDIA DOCK ROAD · LONDON · E.14
Telephones: East 3838 (3 lines), 1408 & 4160 *Grams: Blundell Phone, London*



STAINLESS TUBES & FLANGES

We offer in approved grades of Stainless Steel

- ★ FLANGES MACHINED TO B.S. TABLES OR TO SPECIAL SIZES
- ★ SOLID DRAWN TUBES—FABRICATED PIPES
- ★ ROUND and HEXAGON BAR
- ★ PROFILES CUT TO ANY THICKNESS OR SIZE
- ★ CASTINGS TO CUSTOMERS SPECIFICATION

Keen Prices — Prompt Delivery

Send enquiries to Dept. N.P.

STAINLESS STEEL PROFILE CUTTERS LTD.

Farfac Works, Kings Grove, MAIDENHEAD. *'phone* 1522/23.

ADVERTISERS IN THIS ISSUE

Abingdon King Dick 173
Albright & Wilson (Mfg) Ltd 9
American Machine & Foundry Co. 20
Appleby & Ireland Ltd 31
Armstrong Whitworth Aircraft Ltd, Sir W. G. 10
Associated Lead Manufacturers Ltd 48
Atlas Steel Foundry & Eng. Co. Ltd. The 172
Atomics International 22

Babcock & Wilcox Ltd 11
Bailey & Co. Ltd, Sir W. H. 176
Birmetals Ltd 143
Blakeborough & Son, Ltd, J. 137
Blundell & Crompton Ltd 183
Boving & Co. Ltd 155
Bristol Siddeley Engines Ltd 30
British Acheson Electrodes Ltd 149
British Ermeto Corp. Ltd 133
British Industrial Eng. Co. (Staffs) Ltd 72
British Paints Ltd 50
Burgess Products Co. Ltd 61
Butterfield Ltd, W. P. 44
Butters Bros & Co. Ltd 142

Carlisle & Co. Ltd, C. G. 178
Carter & Viner 148
Central Electricity Generating Board, The 21
Clay Cross (Iron & Foundries) Ltd 83
Cockburns Ltd 145
Consolidated Pneumatic Tool Co. Ltd 52, 53
Cox & Danks Ltd 162
Crossley Brothers Ltd 66

Darlington Forge Ltd, The 64
Darlington Insulation Co. Ltd, The 59
Dewrance & Co., Ltd 70
Distillers Co. Ltd, The 60
Doncaster & Sons Ltd, Daniel 158
Donkin Co. Ltd, The Bryan 148
Dzus Fastener Europe Ltd 169

Ekco Electronics Ltd 19
Electric Resistance Furnace Co. Ltd 54
Electronic Associates Ltd 36
Electronic Switchgear (London) Ltd 174
Ellison Ltd, George 161
E.M.I. Electronics Ltd (Instrument Division) 135
Endecotts (Filters) Ltd 180
English Electric Co. Ltd, The 11
Ericsson Telephones Ltd 26
Esso Petroleum Co. Ltd 23
Evers, D. H. 181
Evershed & Vignoles Ltd 12, 13

Fairey Engineering Ltd 39
Fielden Electronics Ltd 14
Firth & John Brown Ltd, Thos. 49
Fonderie de Gentilly 173
Foster Wheeler Ltd 166

General Electric Co. Ltd, The 186
Gordon & Co. Ltd, James 171
Grace & Co., W. R. 68
Grey & Marten Ltd 158
Gummers Ltd 168, 176

Harlow Printing Works (Northern) Ltd 177
Harvey & Co. (London) Ltd, G. A. 56
Hawker Siddeley Nuclear Power Co. Ltd 34
Hayward Tyler & Co. Ltd 67
Hindle & Sons Ltd, Joshua 37
Holland Eng. Co. Ltd, The B. A. 156
Hopkinsons Ltd 153
Howden & Co. Ltd, James 2
Hunt Heat Exchangers Ltd 184

Imhof Ltd, Alfred 165
Imperial Aluminium Co. Ltd 147
Imperial Chemical Industries Ltd 82
Industries Atomiques 154
International Meehanite Metal Co. Ltd. The 138

Jansen S.A., Th. 175
Jarrow Metal Industries Ltd 41
Joy-Sullivan Ltd 58

Kennedy & Co. Ltd, Allan 74
Kidde Co. Ltd, The Walter 160

Langley Alloys Ltd 17
Lockheed Precision Products Ltd 141
Lodge Plugs Ltd 169
LP-Gas Equipment Ltd 180
Lyons Ltd, Claude 164

Madan & Co. Ltd, Charles S. 160
Magnetic Valve Co. Ltd, The 32, 33
Mancuna Engineering Ltd 57
Marshall of Cambridge Ltd 152
Marston Excelsior Ltd 55
M.B. Metals Ltd 178
Milne & Co. Ltd, C. S. 152
Mirrlees, Bickerton & Day Ltd 140
Mollart Eng. Co. Ltd 174
Morris Ltd, B. O. 65
Morris Ltd, Herbert 40
Mountford (Birmingham) Ltd, Frederick 162
Mullard Ltd 84
Murex Welding Processes Ltd 167

Newalls Insulation Co. Ltd 35
Newman Hender & Co. Ltd 139
Newnes Ltd, George 136
N.G.N. Electrical Ltd 164
Nuclear Equipment Ltd 77
Nuclear Measurement Corp. 172
Nuclear Power Group 185
Nu-Swift Ltd 7

Osborn & Co. Ltd, Samuel 78

Palatine (Surbiton) Ltd 177
Pantak Ltd 154
Pascall Eng. Co. Ltd, The 179
Payne & Griffiths Ltd 150
Phoenix-Rheinrohr Ag 8
Plannair Ltd 63
Plessey Nucleonics Ltd 79
Powell Duffryn Carbon Products Ltd 24
Power Auxiliaries Ltd 76
Premier Cooler & Eng. Co. Ltd, The 179
Pyrotenax Ltd 4

Radiospares Ltd 150
Ransome & Marles Bearing Co. Ltd 16
Research & Control Instruments Ltd 5, 170
Richardsons, Westgarth & Co. Ltd 146
Rio Tinto Management Services (U.K.) Ltd 75
Robertson & Ferguson Ltd 45
Rocol Ltd 163
Rotax Ltd 71
Rotork Eng. Co. Ltd 157
Ryder & Co. (Manchester) Ltd, Thos. 171

Shell Mex & B.P. Ltd 42, 43
Siebe, Gorman & Co. Ltd 168
Simmonds Ltd, L. E. 177
Skinningrove Iron Co. Ltd 6
Spanner Boilers Ltd 144
Stahl-Armaturen Siepmann G.m.b.h., K.G. 18
Stainless Steel Profile Cutters Ltd 184
Staveley Iron & Chemical Co. Ltd, The 170

Taylor Rustless Fittings Co. Ltd, The 159
Taylor Woodrow Construction Ltd 11
Teddington Aircraft Controls Ltd 131
Texas Instruments Inc. 129
Thornton Ltd, B. 151
Tubela Eng. Co. Ltd 176

Uni-Tubes Ltd 175
Union Carbide Ltd 179
Unistrut Division of Sankey-Sheldon Ltd 15
Unit Superheater & Pipe Co. Ltd, The 27

Vacu-Blast Ltd 180
Vallourec S.A. 25
Vokes Ltd 38
Vokes Genspring Ltd 166

Wandleside Cable Works Ltd 51
Walker & Co. Ltd, James 69
Williams & James (Engineers) Ltd 156
Worthington-Simpson Ltd 73

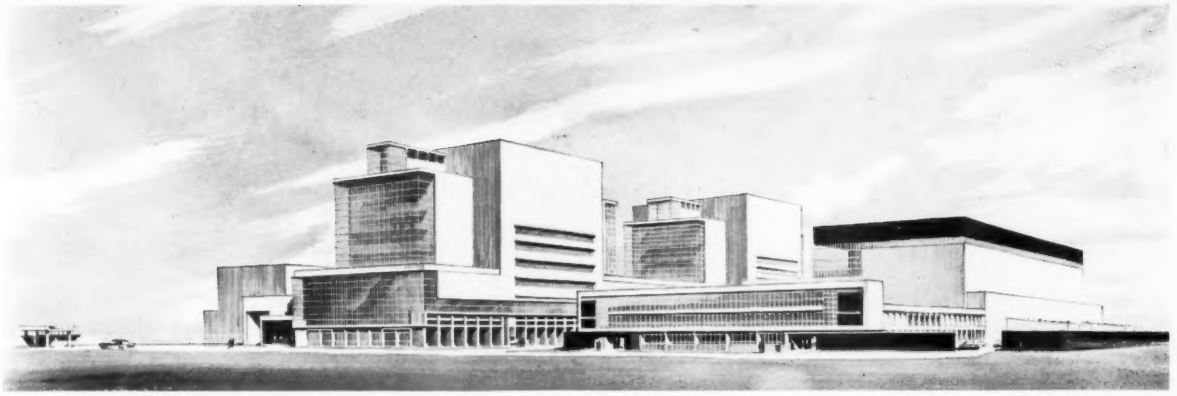
★ Please send for our comprehensive leaflet, which gives technical data and details of applications quoting ref. NP2

HUNT HEAT TRANSFER EQUIPMENT

HUNT HEAT EXCHANGERS LTD.
MIDDLETON MANCHESTER

London Office: Temple Chambers, Temple Avenue, E.C.4.
Telephone: Ludgate Circus 7796/7

HH 2

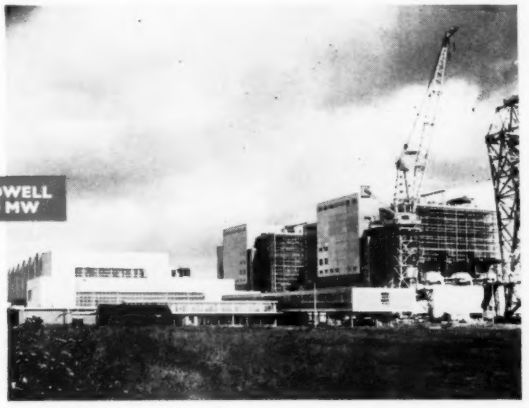


...and now

DUNGENESS

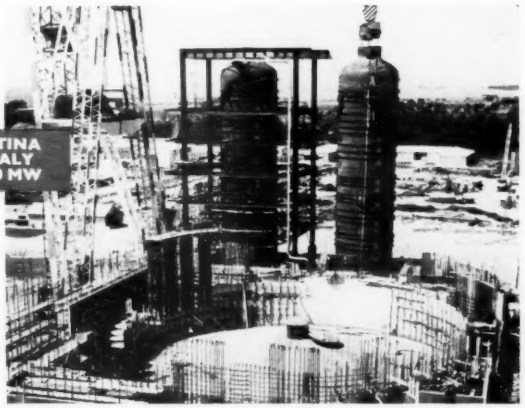
—550 MW

On the shingled headland of Dungeness, Kent, Britain's newest and largest nuclear power station is being built by The Nuclear Power Group for the Central Electricity Generating Board. The station will incorporate the latest developments in reactor technology and will be the most efficient of its kind. Dungeness is the outcome of experience and know-how, for The Nuclear Power Group are also constructing Britain's first two nuclear power stations at Berkeley and Bradwell and the Italian station at Latina near Rome.



BRADWELL —300 MW

BERKELEY —275 MW



LATINA ITALY —200 MW

TNPG ... *leaders in nuclear power*

The Nuclear Power Group

RADBROKE HALL
KNUTSFORD · CHESHIRE

ASSOCIATED ELECTRICAL INDUSTRIES LTD.
CLARKE, CHAPMAN AND COMPANY LTD.
ALEX FINDLAY AND COMPANY LIMITED.
HEAD, WRIGHTSON AND COMPANY LIMITED.
SIR ROBERT MCALPINE AND SONS LTD.
C. A. PARSONS AND COMPANY LIMITED.
A. REYROLLE AND COMPANY LIMITED.
STRACHAN AND HENSHAW LIMITED.
JOHN THOMPSON LIMITED.
WHESSOE LIMITED.

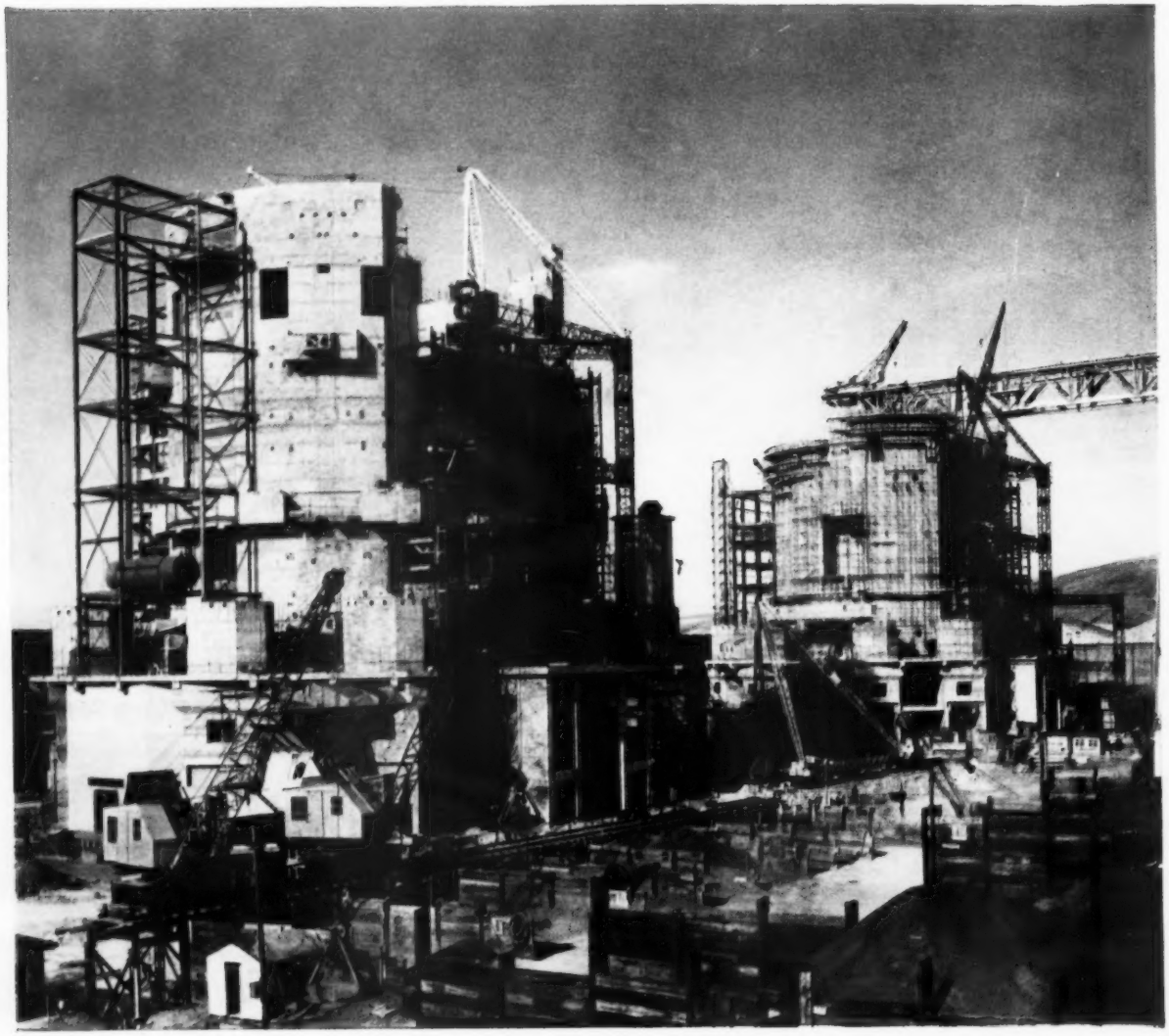
TNPG/2

Circle **No 207** on reply card for further details

Nuclear Power

REACTORS · MATERIALS · INSTRUMENTATION · PROCESSES · IRRADIATION

growing day by day...



at Hunterston in Ayrshire, one of the world's first full-scale nuclear power stations which will produce 320,000 kW for the South of Scotland Electricity Board.

G.E.C.

AND SIMON-CARVES LTD

ATOMIC ENERGY GROUP

HEADQUARTERS: THE GENERAL ELECTRIC CO. LTD. OF ENGLAND, ERITH, KENT

393